MK UNIVERSITY

PATAN, GUJARAT

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MK University, Patan
Faculty of Engineering Technology,
Department of Mechanical Engineering

B. TECH (MECHANICAL ENGINEERING) SEM-I

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION INTERNAL	EXAMINATION EXTERNAL	TOTAL MARKS
1	MAJOR	BTME101	ENGINEERING MATHEMATICS-I	4	0	4	40	60	100
2	MAJOR	BTME102	ENGINEERING PHYSICS	4	0	4	40	60	100
3	MAJOR	BTME103	ENGINEERING CHEMISTRY	4	0	4	40	60	100
4	MAJOR	BTME104	ENGINEERING GRAPHICS & CAD	3	2	5	40	60	100
5	MINOR	BTME105	PROGRAMMING FOR ENGINNEERS (PYTHON)	3	2	5	40	60	100
6	VAC	BTME106	COMMUNICATION SKILLS- I	2	0	2	0	50	50
TOTAL				20	4	24	200	350	550

B. TECH (MECHANICAL ENGINEERING) SEM-II

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION INTERNAL	EXAMINATION EXTERNAL	TOTAL MARKS
1	MAJOR	BTME201	ENGINEERING MATHEMATICS-II	4	0	4	40	60	100
2	MAJOR	BTME202	ENGINEERING MECHANICS	4	0	4	40	60	100
3	MAJOR	BTME203	MATERIALS SCIENCE & ENGINEERING	4	0	4	40	60	100
4	MAJOR	BTME204	WORKSHOP PRACTICE	0	4	4	100	00	100
5	MINOR	BTME205	ENVIRNMENTAL SCIENCE	3	0	3	40	60	100
6	VAC	BTME206	INDIAN CONSTITUTION	2	0	2	0	50	50
TOTAL				17	4	21	260	290	550

B. TECH (MECHANICAL ENGINEERING) SEM-III

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTME301	THERMO DYNAMICS	4	0	4	40	60	100
2	MAJOR	BTME302	FLUID MECHANICS	4	0	4	40	60	100
3	MAJOR	BTME303	MANUFACTURING PROCESS	4	0	4	40	60	100
4	MAJOR	BTME304	STRENGTH OF MATERIALS	4	0	4	40	60	100
5	MINOR	BTME305	BASICS ELECTRONICS & INSTRUMENTATION	3	2	5	40	60	100
6	SEC	BTME306	CAD LAB	0	2	2	50	0	50
TOTAL				19	4	23	250	300	550

B. TECH (MECHANICAL ENGINEERING) SEM-IV

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTME401	HEAT TRANSFER	4	0	4	40	60	100
2	MAJOR	BTME402	MACHINE DESIGN-I	4	0	4	40	60	100
3	MAJOR	BTME403	THEORY OF MACHINES	4	0	4	40	60	100
4	MAJOR	BTME404	METROLOGY & MEASUREMENT	3	2	5	40	60	100
5	MINOR	BTME405	INDUSTRIAL MANAGEMENT	3	0	3	40	60	100
6	SEC	BTME406	CNC PROGRAMMING LAB	0	2	2	0	50	50
TOTAL				18	4	22	200	350	550

B. TECH (MECHANICAL ENGINEERING) SEM-V									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTME501	INTERNAL COMBUSTION ENGINES	4	0	4	40	60	100
2	MAJOR	BTME502	REFRIGERATION & AIR CONDITIONING	4	0	4	40	60	100
3	MAJOR	BTME503	MACHINE DESIGN-II	4	0	4	40	60	100
4	MAJOR	BTME504	CAD/CAM	3	2	5	40	60	100
5	MINOR	BTME505	OPERATIONS RESEARCH	3	0	3	40	60	100
6	SEC	BTME506	MIN PROJECT	0	2	2	50	0	50
TOTAL				18	4	22	250	300	350

B. TECH (MECHANICAL ENGINEERING) SEM-VI									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTME601	AUTOMOBILE ENGINEERING	4	0	4	40	60	100
2	MAJOR	BTME602	FINITE ELEMENT ANALYSIS	3	2	5	40	60	100
3	MAJOR	BTME603	MECHATRONICS	3	2	5	40	60	100
4	MINOR	BTME604	ROBOTICS & AUTOMATION	3	0	3	40	60	100
5	SEC	BTME605	ADDITIVE MANUFACTURING LAB	0	2	2	100	00	100
6	SEC	BTME606	Aptitude & Career Skills	0	2	2	50	0	50
TOTAL				13	8	21	310	240	550

B. TECH (MECHANICAL ENGINEERING) SEM-VII

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION INTERNAL	EXAMINATION EXTERNAL	TOTAL MARKS
1	MAJOR	BTME701	POWER PLANT ENGINEERING	4	0	4	40	60	100
2	MAJOR	BTME702	VIBRATIONS & NOISE CONTROL	3	2	5	40	60	100
3	MINOR	BTME703	RENEWABLE ENERGY SYSTEMS	3	0	3	40	60	100
4	MULTI DISCIPLINARY (MD)	BTME704	ENTERPRENURSHIP FOR ENGINEERS	3	0	3	40	60	100
5	SEC	BTME705	INDUSTRIAL TRAINIG	0	2	2	100	00	100
6	SEC	BTME706	Project Phase-I	0	4	4	50	00	50
TOTAL				13	8	21	310	240	550

B. TECH (MECHANICAL ENGINEERING) SEM-VIII

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION INTERNAL	EXAMINATION EXTERNAL	TOTAL MARKS
1	MAJOR	BTME801	COMPOSITE MATERIALS	3	0	3	40	60	100
2	MAJOR	BTME802	COMPUTATIONAL FLUID DYNAMICS	3	2	5	40	60	100
4	SEC	BTME804	INTERNSHIP	0	4	4	100	00	100
5	SEC	BTME805	Project Phase-II	0	10	10	100	150	250
TOTAL				6	16	22	280	270	550

SEMESTER-I

SUBJECT CODE: BTME101

SUBJECT NAME: ENGINEERING MATHEMATICS-I

Course Objective:

- The concept of rank of a matrix which is used to know the consistency of system of linear equations and also to find the eigen vectors of a given matrix.
- Finding maxima and minima of functions of several variables.
- Applications of first order ordinary differential equations. (Newton's law of cooling, Natural growth and decay)
- How to solve first order linear, nonlinear partial differential equations and also method of separation of variables technique to solve typical second order partial differential equations.
- Solving differential equations using Laplace Transforms.

Course Outcomes: At the end of the course students shall be able to

CO1	The concept of rank of a matrix which is used to know the consistency of system of linear equations and also to find the eigen vectors of a given matrix
CO2	Finding maxima and minima of functions of several variables
C03	Applications of first order ordinary differential equations
C04	How to solve first order linear, nonlinear partial differential equations and also method of separation of variables technique to solve typical second order partial differential equations
CO5	

Unit	Content	Credit	Weightage
I	Matrices Introduction, types of matrices-symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal, unitary matrices. Rank of a matrix - echelon form, normal form, consistency of system of linear equations (Homogeneous and Non-Homogeneous). Eigen values and Eigen vectors and their properties (without proof), Cayley-Hamilton theorem (without proof), Diagonalization.	1	25%
II	Functions of Several Variables Limit continuity, partial derivatives and total derivative. Jacobian-Functional dependence and independence. Maxima and minima and saddle points, method of Lagrange multipliers, Taylor's theorem for two variables.	1	25%
III	Ordinary Differential Equations First order ordinary differential equations: Exact, equations reducible to exact form. Applications of first order differential equations - Newton's law of cooling, law of natural growth and decay. Linear differential equations of second and higher order with constant coefficients: Non-homogeneous term of the	1	25%

	type f(x) = eax, sinax, cosax, xn , eax V and xn V. Method of variation of parameters.		
IV	Partial Differential Equations Introduction, formation of partial differential equation by elimination of arbitrary constants and arbitrary functions, solutions of first order Lagrange's linear equation and non-linear equations, Charpit's method, Method of separation of variables for second order equations and applications of PDE to one dimensional (Heat equation).	1	25%

TEXT BOOKS:
1. Higher Engineering Mathematics by B V Ramana ., Tata McGraw Hill.
2. Higher Engineering Mathematics by B.S. Grewal, Khanna Publishers.
3. Advanced Engineering Mathematics by Kreyszig, John Wiley & Sons.

REFERENCE BOOKS:
i)Advanced Engineering Mathematics by R.K Jain & S R K Iyenger, Narosa Publishers.
ii)Advanced Engineering Mathematics by Michael Green Berg, Pearson Publishers
iii)Engineering Mathematics by N.P Bali and Manish Goyal

SUBJECT CODE: BTME102

SUBJECT NAME: ENGINEERING PHYSICS

Course Outcomes: At the end of the course students shall be able to

CO1	Gain the knowledge on the basic concepts of oscillations exhibited by various systems in nature
CO2	Study the basic concepts of light through interference and diffraction
C03	Explore band structure of the solids and classification of materials
C04	Compare dielectric and magnetic properties of the materials and enable them to design and apply in different fields

Unit	Content	Credit	Weightage
I	HARMONIC OSCILLATIONS: Introduction to harmonic oscillators, simple harmonic oscillator: equation of motion and its solution (complex exponential method), damped harmonic oscillator: equation of motion and its solution, over, critical and lightly-damped oscillators; energy decay in damped harmonic oscillator, Quality factor (qualitative), forced damped harmonic oscillator: equation of motion and its solution.	1	25%
II	WAVEOPTICS: Interference- Introduction, Superposition of waves, interference of light by division of wave front-	1	25%

	interference of reflected light in thin films, interference of light by division of amplitude Newton's rings, Diffraction-difference between Fresnel and Fraunhofer diffraction, Fraunhofer diffraction due to single slit, Diffraction grating- Grating spectrum and resolving power.		
III	INTRODUCTION TO SOLIDS: Free electron theory (Classical & Quantum): Assumptions, Merits and drawbacks, Fermi level, Density of states, Periodic potential, Bloch's theorem, Kronig – Penny modal, E – K diagram, Effective mass, Origin of energy bands in solids, Classification of materials: Metals, semi-conductors and insulators.	1	25%
IV	Dielectrics: Introduction, Types of polarizations (Electronic and Ionic) and calculation of their polarizabilities, internal fields in a solid, Clausius-Mossotti relation. Magnetism: Introduction, Bohr magneton, classification of dia, para and ferro magnetic materials on the basis of magnetic moment, Properties of anti-ferro and ferri magnetic materials, Hysteresis curve based on Domain theory of ferro magnetism, Soft and hard magnetic materials.	1	25%

TEXT BOOKS:

1. Engineering Physics by Arumugam, Anuradha publications.
2. Engineering Physics- B.K. Pandey, S. Chaturvedi, Cengage Learning.

REFERENCE BOOKS:

1. Engineering Physics – R.K. Gaur and S.L. Gupta, DhanpatRai Publishers.
2. Engineering Physics, S Mani Naidu- Pearson Publishers.
3. Engineering physics 2nd edition –H.K. Malik and A.K. Singh.
4. Engineering Physics – P.K. Palaniswamy, Scitech publications.
5. Physics by Resnick and Haliday.

SUBJECT CODE: BTME103

SUBJECT NAME: ENGINEERING CHEMISTRY

Course Outcomes: At the end of the course students shall be able to

CO1	Apply electrochemical principles to corrosion prevention in mechanical systems.
CO2	Analyze fuels, lubricants, and alternative energy sources for efficient engineering applications.
C03	Select appropriate polymers, composites, and nanomaterials for mechanical design.
C04	Implement water treatment and environmental protection measures in engineering projects.

Unit	Content	Credit	Weightage
I	**ELECTROCHEMISTRY & CORROSION** • **Electrochemical Cells:** Galvanic and electrolytic cells, EMF, Nernst equation. • **Batteries:** Primary and secondary batteries (Li-ion, lead-acid, Ni-Cd), fuel cells. • **Corrosion:** Types (chemical, electrochemical), factors affecting corrosion. • **Corrosion Control:** Cathodic and anodic protection, coatings, inhibitors. • **Relevance to Mechanical Systems:** Pipeline corrosion, automotive parts, marine structures.	1	25%
II	**ENERGY SOURCES, FUELS & LUBRICANTS** • **Conventional Fuels:** Coal, petroleum, natural gas – classification, properties, refining. • **Alternative Energy Sources:** Hydrogen, biofuels, solar cells, nuclear energy. • **Combustion:** Stoichiometry, calorific value, flue gas analysis. • **Lubricants:** Types (solid, liquid, semi-solid), properties, additives, selection criteria. • **Engineering Applications:** IC engines, turbines, gear systems.	1	25%
III	**ENGINEERING MATERIALS: POLYMERS, COMPOSITES & NANOMATERIALS** • **Polymers:** Classification, polymerization, properties (Tg, Tm), mechanical behavior. • **Engineering Polymers:** PVC, nylon, epoxy, PTFE, fiber-reinforced polymers. • **Composites:** Matrix and reinforcement, types, applications in automotive/aerospace. • **Nanomaterials:** Synthesis, properties, CNTs, graphene, nanocomposites. • **Material Selection:** For lightweight design, wear resistance, thermal stability.	1	25%
IV	**WATER CHEMISTRY & ENVIRONMENTAL ENGINEERING** • Water Quality Parameters: Hardness, alkalinity, DO, BOD, COD. • Water Treatment: Softening (lime-soda, ion exchange), desalination, purification. • Boiler Feed Water: Scale and sludge formation, treatment, blowdown. • Environmental Pollution: Air, water, soil pollutants, control measures. Green Chemistry: Principles, sustainable engineering practices.	1	25%

TEXT BOOKS:

1. **Engineering Chemistry** – Jain & Jain
2. **Engineering Chemistry** – Shashi Chawla

3. **A Textbook of Engineering Chemistry** – S.S. Dara
4. **Engineering Chemistry: Fundamentals and Applications** – Shikha Agarwal

REFERENCE BOOKS:

1. **Chemistry for Engineers** – J.O.M. Bockris
2. **Material Science and Engineering: An Introduction** – William D. Callister
3. **Corrosion Engineering** – Mars G. Fontana
4. **Polymer Science and Technology** – Joel R. Fried
5. **Environmental Chemistry** – A.K. De

SUBJECT CODE: BTME104

SUBJECT NAME: ENGINEERING GRAPHICS AND CAD

Course Objectives:

- To develop spatial visualization skills for interpreting and creating engineering drawings.
- To introduce manual drafting techniques using standard drawing instruments.
- To impart proficiency in Computer-Aided Design (CAD) software for 2D and 3D modeling.
- To apply geometric dimensioning and tolerancing (GD&T) principles in mechanical design.
- To prepare students for creating manufacturing-ready drawings and assemblies.
- To integrate CAD with modern engineering workflows and design thinking.

Course Outcomes: At the end of the course students shall be able to

CO1	Create and interpret engineering drawings using standard conventions (BIS/ISO).
CO2	Construct orthographic, isometric, and sectional views of mechanical components.
C03	Develop 3D solid models and assemblies using CAD software (SolidWorks/AutoCAD).

Unit	Content	Credit	Weightage
I	**FUNDAMENTALS OF ENGINEERING DRAWING** • **Drawing Instruments & Standards:** Use of drawing tools, BIS/ISO standards, sheet layout, title block. • **Lettering & Line Types:** Engineering lettering (single stroke), types of lines (visible, hidden, center, section). • **Geometric Constructions:** Bisection, division of lines, tangency, polygons, conic sections. • **Scales:** Plain, diagonal, vernier scales, scale selection for drawings. • **Dimensioning:** Aligned and unidirectional systems, chain and parallel dimensioning, rules.	1	30%
II	**ORTHOGRAPHIC PROJECTIONS & SECTIONS** • **Projection Principles:** First-angle vs. third-angle projection, projection of points and lines. • **Orthographic Views:** Front, top, side views of simple and complex objects, missing view problems. • **Auxiliary Views:** Primary and secondary auxiliary projections for inclined surfaces. • **Sectional Views:** Full, half, offset, aligned, and broken-out sections, section lining conventions.	1	35%

	• **Conventional Practices:** Simplified representation of threads, springs, gears, and welded joints.		
III	**PICTORIAL & DEVELOPMENT DRAWINGS** • **Isometric Projection:** Isometric axes, isometric scale, construction of isometric views from orthographic. • **Perspective Drawing:** One-point and two-point perspective basics. • **Development of Surfaces:** Parallel-line and radial-line development of prisms, cylinders, cones, and transitions. • **Intersection of Solids:** Interpenetration of cylinders, prisms, and cones, line of intersection. • **Applications:** Sheet metal layouts, ducting, piping, and container design.	1	35%

TEXT BOOKS:

- Engineering Drawing – N.D. Bhatt (Charotar Publishing)
- Engineering Drawing with CAD – M.B. Shah & B.C. Rana (Pearson)
- Engineering Graphics – K.V. Natarajan (SCItech Publications)
- AutoCAD 2023: A Problem-Solving Approach – Sham Tickoo (CADCIM Technologies)

REFERENCE BOOKS:

- Technical Drawing – Giesecke, Mitchell, Spencer (Pearson)
- Engineering Design: A CAD Approach – A. Deane, C. McAdams (Wiley)
- SolidWorks 2023 for Engineers and Designers – Prof. Sham Tickoo (CADCIM)
- Geometric Dimensioning and Tolerancing – James D. Meadows (CRC Press)

LIST OF PRACTICALS:

- Lab 1: Use of drawing instruments, lettering practice, geometric constructions.
- Lab 2: Orthographic projections of simple objects (first-angle projection).
- Lab 3: Orthographic projections of objects with inclined surfaces.
- Lab 4: Sectional views of machine components (full, half, offset sections).
- Lab 5: Isometric drawing from given orthographic views.
- Lab 6: Development of lateral surfaces of prism, cylinder, and cone.
- Lab 7: Introduction to CAD software – basic commands, coordinate input, drawing setup.
- Lab 8: 2D drafting – drawing and editing commands, layers, dimensioning.
- Lab 9: 3D solid modelling – extrude, revolve, Boolean operations.
- Lab 10: Advanced 3D modelling – sweep, loft, shell, fillet, chamfer.
- Lab 11: Assembly modelling – inserting parts, applying mates, interference check.
- Lab 12: Drawing sheet creation – views, annotations, GD&T, BOM, plotting.

SUBJECT CODE: BTME105

SUBJECT NAME: PROGRAMMING FOR ENGINEERS (PYTHON)

Course Objectives:

- To introduce Python programming fundamentals for solving engineering problems.
- To develop computational thinking and algorithmic problem-solving skills.
- To apply Python for data analysis, visualization, and simulation in mechanical engineering.
- To integrate Python with engineering tools (CAD, simulation, IoT) and automation workflows.
- To prepare students for using Python in data-driven design, optimization, and research.
- Course Outcomes: At the end of the course students shall be able to

CO1	Write, debug, and execute Python programs using control structures and functions.
CO2	Apply data structures (lists, tuples, dictionaries, arrays) for engineering data handling.
C03	Use Python libraries (NumPy, Matplotlib, Pandas) for numerical analysis and visualization.

Unit	Content	Credit	Weightage
I	PYTHON FUNDAMENTALS & CONTROL STRUCTURES Introduction to Python, Operators & Expressions, Input/Output, Control Structures, Functions, Error Handling	1	30%
II	DATA STRUCTURES & MODULAR PROGRAMMING Built-in Data Structures, Strings, Modules & Packages, File Handling, Object-Oriented Programming (Basics)	1	35%
III	ENGINEERING APPLICATIONS WITH PYTHON LIBRARIES Scientific Computing, Data Visualization, Data Analysis, Engineering Applications, Introduction to APIs & Web Scraping	1	35%

TEXT BOOKS:

- Python Programming: A Modern Approach – Vamsi Kurama (Pearson)
- Python for Engineers – Dr. R. R. Lakshmi (Wiley)
- Automate the Boring Stuff with Python – Al Sweigart (No Starch Press)
- Python for Data Analysis – Wes McKinney (O'Reilly)

REFERENCE BOOKS:

- Effective Python: 90 Specific Ways to Write Better Python – Brett Slatkin
- Introduction to Python for Engineers and Scientists – Sandeep Nagar (Apress)
- Numerical Python: Scientific Computing and Data Science Applications – Robert Johansson
- Python for Mechanical and Aerospace Engineering – Alex Kenan (Springer)
- Think Python: How to Think Like a Computer Scientist – Allen B. Downey

LIST OF PRACTICALS:

- Exp 1: Basic Python programs: variables, operators, input/output.
- Exp 2: Conditional statements: grading system, BMI calculator, leap year checker.
- Exp 3: Loops: factorial, Fibonacci series, prime number detection, pattern printing.
- Exp 4: Functions: reusable functions for engineering calculations (area, volume, conversions).
- Exp 5: Lists and tuples: student marks processing, temperature data analysis.
- Exp 6: Dictionaries and sets: inventory system, frequency analysis of words.
- Exp 7: String manipulation: parsing engineering data files, unit conversion scripts.
- Exp 8: File handling: reading/writing CSV files, log file analysis, data export.
- Exp 9: NumPy: matrix operations, solving linear equations, statistical analysis of experimental data.
- Exp 10: Matplotlib: plotting stress-strain curves, temperature distribution, motion graphs.
- Exp 11: Pandas: analyzing sensor data (vibration, temperature), generating summary reports.

SEMESTER-II

SUBJECT CODE: BTME201

SUBJECT NAME: ENGINEERING MATHAMTICS-II

Course Outcomes: At the end of the course students shall be able to

CO1	**Apply** linear algebra concepts (eigenvalues, SVD) to problems in computer graphics, data compression, and machine learning.
CO2	**Formulate** and **solve** probability models for analysing randomized algorithms, network reliability, and performance evaluation.
C03	**Model** computational problems using graph theory and solve basic graph algorithms relevant to networks and data structures.
C04	**Implement** numerical methods for solving mathematical problems computationally with error analysis awareness.

Unit	Content	Credit	Weightage
I	**Advanced Linear Algebra** • **Vector Spaces:** Definition, subspaces, linear independence, basis, dimension • **Linear Transformations:** Matrix representation, kernel, image, rank-nullity theorem • **Eigenvalues and Eigenvectors:** Computation, properties, diagonalization • **Singular Value Decomposition (SVD):** Geometric interpretation, applications in data science • **Matrix Factorization:** LU, QR decompositions (algorithmic perspective)	1	25%

II	**Probability Theory for Computer Science**
	• **Probability Basics:** Axioms, conditional probability, Bayes' theorem
	• **Random Variables:** Discrete and continuous, PMF/PDF, CDF
	• **Important Distributions:**
	  o Discrete: Bernoulli, Binomial, Poisson, Geometric
	  o Continuous: Uniform, Normal, Exponential
	• **Expectation and Variance:** Properties, moments
	• **Joint Distributions:** Covariance, correlation, independence
	• **Law of Large Numbers & Central Limit Theorem:** Conceptual understanding
		1	25%

III	**Discrete Mathematics** • **Graph Theory:** Basic terminology, types of graphs, connectivity • **Special Graphs:** Trees, bipartite graphs, planar graphs	1	25%

	• **Graph Algorithms:** Shortest path (conceptual), graph coloring • **Combinatorics:** Counting principles, permutations, combinations • **Recurrence Relations:** Formulation, solving using characteristic equations		
IV	**Numerical Methods for CS Applications** • **Numerical Linear Algebra:** Solving linear systems (Gaussian elimination, iterative methods) • **Numerical Integration:** Trapezoidal rule, Simpson's rule • **Root Finding:** Bisection method, Newton-Raphson method • **Error Analysis:** Round-off error, truncation error, stability	1	25%

Textbooks:

- Linear Algebra and Its Applications by Gilbert Strang (for Module 1)
- Introduction to Probability by Dimitri P. Bertsekas and John N. Tsitsiklis (for Module 2)
- Discrete Mathematics and Its Applications by Kenneth H. Rosen (for Module 3)

Reference books:

- Numerical Recipes by Press et al. (for Module 4)
- Convex Optimization by Boyd and Vandenberghe (for Module 5)
- Mathematics for Computer Science (MIT Open Course Ware)

Digital Resources:

- 3Blue1Brown YouTube series (linear algebra, calculus)
- Khan Academy probability and linear algebra modules

Jupyter notebooks for computational examples

SUBJECT CODE: BTME202

SUBJECT NAME: ENGINEERING MECHANICS

Course Objectives:

- To introduce the fundamental principles of statics, dynamics, and mechanics of materials.
- To develop analytical skills for solving problems involving forces, equilibrium, and motion.
- To apply principles of mechanics to analyse structures, machines, and mechanical systems.
- To prepare students for advanced courses in solid mechanics, machine design, and dynamics.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze force systems and compute resultants for particles and rigid bodies.
CO2	Apply equilibrium conditions to solve problems in statics for trusses, beams, and frames.
C03	Determine centroids, moments of inertia, and analyze friction in mechanical systems.
C04	Solve kinematics and kinetics problems for particles and rigid bodies in motion.

Unit	Content	Credit	Weightage
I	STATICS OF PARTICLES & RIGID BODIES Introduction to Mechanics, Force Systems, Resultant of Force Systems, Equilibrium of Particles, Moment of a Force, Rigid Body Equilibrium	1	25%
II	ANALYSIS OF STRUCTURES Trusses, Frames and Machines, Beams, Cables and Arches, Friction	1	25%
III	PROPERTIES OF SURFACES AND DISTRIBUTED FORCES Centroid, Centre of Gravity, Moment of Inertia, Mass Moment of Inertia, Virtual Work	1	25%
IV	DYNAMICS OF PARTICLES AND RIGID BODIES Kinematics of Particles, Kinetics of Particles, Kinematics of Rigid Bodies, Kinetics of Rigid Bodies, Vibrations	1	25%

Textbooks:

- Engineering Mechanics: Statics and Dynamics – R.C. Hibbeler (Pearson)
- Engineering Mechanics – S. S. Bhavikatti and K. G. Rajashekarappa (New Age International)
- Engineering Mechanics: Statics & Dynamics – Irving H. Shames (Prentice Hall)
- Engineering Mechanics: Statics and Dynamics – J.L. Meriam and L.G. Kraige (Wiley)

Reference books:

- Vector Mechanics for Engineers: Statics and Dynamics – Beer and Johnston (McGraw Hill)
- Engineering Mechanics – D.S. Bedi (Khanna Publishers)
- A Textbook of Engineering Mechanics – R.K. Bansal (Laxmi Publications)
- Engineering Mechanics: Problems and Solutions – K. Vijaya Kumar and J. Suresh Kumar (McGraw Hill)
- Advanced Engineering Mechanics – H.C. Gupta (Standard Publishers)

SUBJECT CODE: BTME203

SUBJECT NAME: MATERIAL SCIENCE AND ENGINEERING

Course Objectives:

- To understand the relationship between material structure, properties, processing, and performance.
- To classify engineering materials and analyse their atomic, crystal, and microstructure.
- To evaluate mechanical properties of materials and their behaviour under different loading conditions.
- To select appropriate materials for mechanical design applications based on engineering requirements.
- To explore modern materials, composites, nanomaterials, and their applications in mechanical engineering.

Course Outcomes: At the end of the course students shall be able to

CO1	Classify engineering materials based on atomic bonding, crystal structure, and properties.
CO2	Analyze crystal defects, phase diagrams, and microstructure-property relationships.
C03	Evaluate mechanical behavior of materials under static, dynamic, and cyclic loading.
C04	Select appropriate materials for mechanical components considering performance and sustainability.

Unit	Content	Credit	Weightage
I	STRUCTURE OF MATERIALS Atomic Structure & Bonding, Crystal Structure, Crystalline & Amorphous Materials, Crystal Imperfections, Diffusion in Solids	1	25%
II	PHASE DIAGRAMS & HEAT TREATMENT Phase Rule & Phase Diagrams, Iron-Carbon Phase Diagram, Heat Treatment Processes, Surface Hardening, TTT & CCT Diagrams	1	25%
III	MECHANICAL PROPERTIES & FAILURE Mechanical Testing, Deformation Mechanisms, Fracture & Fatigue, Fracture Mechanics, Non-Destructive Testing (NDT)	1	25%
IV	ENGINEERING MATERIALS & SELECTION Ferrous Alloys, Non-Ferrous Alloys, Polymers & Ceramics, Composites, Advanced Materials, Material Selection	1	25%

Textbooks:

- Materials Science and Engineering: An Introduction – William D. Callister, Jr. (Wiley)
- Engineering Materials: Properties and Selection – Kenneth G. Budinski (Pearson)
- Material Science and Engineering – V. Raghavan (Prentice Hall India)
- Introduction to Materials Science for Engineers – James F. Shackelford (Pearson)

Reference books:

- The Science and Engineering of Materials – Donald R. Askeland and Wendelin J. Wright (Cengage)
- Elements of Materials Science and Engineering – L. H. Van Vlack (Pearson)
- Mechanical Behaviour of Materials – Norman E. Dowling (Pearson)
- Materials Selection in Mechanical Design – Michael F. Ashby (Butterworth-Heinemann)
- Phase Transformations in Metals and Alloys – David A. Porter and Kenneth E. Easterling (CRC Press)

Online Platforms:

- NPTEL Courses:
  1. "Materials Science and Engineering" by Prof. Satish V. Kailas (IISc Bangalore)
  2. "Introduction to Materials Science" by IIT Madras

SUBJECT CODE: BTME204

SUBJECT NAME: WORKSHOP PRACTICE

Course Objectives:

- To provide hands-on experience with basic workshop tools, machines, and processes.
- To develop skills in measuring, marking, cutting, shaping, and joining engineering materials.
- To introduce manufacturing processes such as casting, machining, welding, and sheet metal work.
- To foster safety awareness and proper handling of workshop equipment.
- To prepare students for practical implementation of mechanical designs and prototypes.

Course Outcomes: At the end of the course students shall be able to

CO1	Operate basic hand tools, measuring instruments, and

	workshop machinery safely.
CO2	Perform fundamental workshop processes such as fitting, carpentry, welding, and machining.
C03	Fabricate simple components using processes like casting, forging, sheet metal work, and turning.
C04	Assemble components and produce small mechanical assemblies or prototypes.
CO5	Interpret engineering drawings and convert them into physical components.

PRACTICAL LIST (12 Sessions):

Session 1: Workshop Safety & Measurement

- Objective: Introduce workshop safety rules and use of measuring tools.
- Tasks:
  1. Workshop safety demonstration and PPE usage.
  2. Use of Vernier caliper, micrometer, and height gauge.
  3. Practice on steel rule, try square, and surface plate.
- Deliverable: Measurement report of given components.

Session 2: Fitting – Marking & Sawing

- Objective: Learn marking tools and hand sawing.
- Tasks:
  1. Use of scriber, center punch, surface gauge, and angle plate.
  2. Cutting mild steel flats using hacksaw.
  3. Filing practice (flat, square, and cross filing).
- Deliverable: A marked and sawn MS piece with dimensional accuracy.

Session 3: Fitting – Drilling & Tapping

- Objective: Perform drilling and thread cutting.
- Tasks:
  1. Use of bench drill machine, drill bits, and reamers.
  2. Drill holes on MS plate and deburr.
  3. Tap internal threads and cut external threads using dies.
- Deliverable: Drilled and tapped component.

Session 4: Carpentry – Wood Working

- Objective: Basic woodworking skills.
- Tasks:
  1. Use of saws, planes, chisels, and mallet.
  2. Make a half-lap joint or mortise-tenon joint.
  3. Sanding and finishing of wooden piece.
- Deliverable: A finished wooden joint.

Session 5: Welding – Arc Welding

- Objective: Introduction to electric arc welding.
- Tasks:
  1. Setting up arc welding machine and electrodes.
  2. Practice bead formation on MS plate.
  3. Make a lap joint or butt joint.
- Deliverable: A welded joint, inspect for defects.

Session 6: Welding – Gas Welding

- Objective: Learn gas welding (oxy-acetylene).
- Tasks:
  1. Set up gas welding kit, adjust flame (neutral, oxidizing, carburizing).
  2. Practice bead on plate, butt joint.

3. Perform brazing of two metal pieces.

- Deliverable: Brazed assembly.

Session 7: Sheet Metal Work

- Objective: Fabricate sheet metal components.
- Tasks:
  1. Use of snips, stakes, mallets, and folding machines.
  2. Develop a rectangular tray or funnel from GI sheet.
  3. Seaming and riveting practice.
- Deliverable: A sheet metal component (e.g., tray, box).

Session 8: Casting – Sand Molding

- Objective: Understand foundry processes.
- Tasks:
  1. Preparation of green sand, molding tools.
  2. Make a split mold using pattern (single piece).
  3. Pour molten metal (demonstration) and inspect casting.
- Deliverable: A sand mold ready for pouring.

Session 9: Forging

- Objective: Basic hot forging operations.
- Tasks:
  1. Use of forge furnace, anvil, hammers, and tongs.
  2. Perform operations: upsetting, drawing, bending, punching.
  3. Forge a simple component like a chisel or round-to-square.
- Deliverable: A forged component.

Session 10: Machining – Lathe Operation

- Objective: Perform basic lathe operations.
- Tasks:
  1. Identify lathe parts, tool holders, chucks.
  2. Perform facing, turning, step turning, and taper turning.
  3. Practice knurling and parting-off.
- Deliverable: A turned MS component with steps.

Session 11: Machining – Shaping & Milling

- Objective: Use shaping and milling machines.
- Tasks:
  1. Perform plain shaping to produce a flat surface.
  2. Use vertical milling machine for slot cutting or face milling.
- Deliverable: A machined block with milled slot/shaped surface.

Session 12: Assembly Practice

- Objective: Assemble multiple components into a working model.
- Tasks:
  1. Use fasteners (nuts, bolts, screws) to assemble parts made in earlier sessions.
  2. Assemble a small tool (e.g., bench vice model, paper cutter, clamp).
  3. Check alignment, fit, and function.
- Deliverable: A fully assembled working model.

SEMESTER-III

SUBJECT CODE: BTME301

SUBJECT NAME: THERMODYNAMICS

Course Objectives:

- To understand the fundamental concepts, laws, and principles of thermodynamics.
- To analyse thermodynamic properties of pure substances and apply property tables/charts.
- To evaluate thermodynamic cycles (power, refrigeration, heat pump) and their performance.
- To develop problem-solving skills for energy conversion, transfer, and utilization in mechanical systems.
- To apply thermodynamic principles to real-world engineering applications (IC engines, power plants, HVAC).

Course Outcomes: At the end of the course students shall be able to

CO1	Apply the zeroth and first laws of thermodynamics to closed and open systems.
CO2	Analyze the properties of pure substances using tables, charts, and equations of state.
C03	Apply the second law to evaluate entropy, irreversibility, and cycle efficiency.
C04	Analyze and design basic power, refrigeration, and heat pump cycles.

Unit	Content	Credit	Weightage
I	BASIC CONCEPTS & ZEROTH LAW Introduction to Thermodynamics, Thermodynamic Properties, Processes & Cycles, Zeroth Law of Thermodynamics, Work & Heat	1	25%
II	FIRST LAW OF THERMODYNAMICS First Law for Closed Systems, First Law for Open Systems, Energy Analysis of Engineering Devices, Thermodynamic Properties of Pure Substances Equations of State	1	25%
III	SECOND LAW OF THERMODYNAMICS Limitations of First Law, Kelvin-Planck & Clausius Statements, Carnot Cycle, Entropy, Irreversibility & Exergy	1	25%
IV	THERMODYNAMIC CYCLES & APPLICATIONS Gas Power Cycles, Vapor Power Cycles, Refrigeration Cycles, Heat Pump Cycles, Psychrometric	1	25%

Textbooks:

- Engineering Thermodynamics – P.K. Nag (McGraw Hill)
- Thermodynamics: An Engineering Approach – Yunus A. Çengel and Michael A. Boles (McGraw Hill)
- Engineering Thermodynamics – D.S. Kumar (S.K. Kataria & Sons)
- Thermodynamics – J.P. Holman (McGraw Hill)

Reference books:

- Fundamentals of Engineering Thermodynamics – Michael J. Moran and Howard N. Shapiro (Wiley)

- Thermodynamics – R.K. Rajput (Laxmi Publications)
- Applied Thermodynamics – T.D. Eastop and A. McConkey (Pearson)
- Thermodynamics and Heat Engines – R. Yadav (Central Publishing House)
- Thermodynamic Cycles: Computer-Aided Design and Optimization – Chih Wu (CRC Press)

Online Platforms:

1. **NPTEL Courses:**
   - "Applied Thermodynamics" by Prof. S.K. Som (IIT Kharagpur)
   - "Thermodynamics" by Prof. M. Ramgopal (IIT Kharagpur)

SUBJECT CODE: BTME302

SUBJECT NAME: FLUID MECHANICS

Course Objectives:

- To understand the fundamental properties and behaviour of fluids under static and dynamic conditions.
- To apply principles of fluid statics, kinematics, and dynamics to solve engineering problems.
- To analyse flow behaviour using continuity, momentum, and energy equations.
- To study flow measurement techniques, boundary layer theory, and drag/lift forces.
- To prepare students for applications in hydraulic machinery, piping systems, and fluid system design.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze fluid properties and hydrostatic forces on submerged surfaces.
CO2	Apply continuity, momentum, and energy equations to fluid flow problems.
C03	Classify fluid flow and analyze flow through pipes, ducts, and open channels.
C04	Evaluate boundary layer effects, drag, lift, and performance of hydraulic machines.

Unit	Content	Credit	Weightage
I	FLUID PROPERTIES & FLUID STATICS Introduction to Fluid Mechanics, Fluid Properties, Fluid Statics, Hydrostatic Forces Fluid Kinematics	1	25%
II	FLUID DYNAMICS & BASIC EQUATIONS Conservation Laws, Bernoulli’s Equation, Energy Equation, Momentum Equation, Dimensional Analysis & Similitude	1	25%
III	FLOW THROUGH PIPES & DUCTS Flow Classification, Laminar Flow, Turbulent Flow, Pipe Flow Analysis, Boundary Layer Theory	1	25%
IV	FLOW MEASUREMENT & HYDRAULIC MACHINERY Flow Measurement Devices, Drag and Lift, Introduction to Compressible Flow, Hydraulic Machines – Pumps, Hydraulic Machines	1	25%

Textbooks:

- Fluid Mechanics – Frank M. White (McGraw Hill)
- Introduction to Fluid Mechanics and Fluid Machines – S.K. Som and G. Biswas (McGraw Hill)

- Fluid Mechanics and Hydraulic Machines – R.K. Bansal (Laxmi Publications)
- Engineering Fluid Mechanics – K.L. Kumar (S. Chand)

Reference books:

- Fluid Mechanics: Fundamentals and Applications – Yunus A. Çengel and John M. Cimbala (McGraw Hill)
- A Textbook of Fluid Mechanics and Hydraulic Machines – R.K. Rajput (S. Chand)
- Fluid Mechanics – Pijush K. Kundu and Ira M. Cohen (Academic Press)
- Fox and McDonald's Introduction to Fluid Mechanics – Robert W. Fox, Alan T. McDonald, Philip J. Pritchard (Wiley)
- Hydraulics and Fluid Mechanics – P.N. Modi and S.M. Seth (Standard Book House)

Online Platforms:

NPTEL Courses:

- "Fluid Mechanics" by Prof. S.K. Som (IIT Kharagpur)
- "Applied Fluid Mechanics" by IIT Roorkee

SUBJECT CODE: BTME303

SUBJECT NAME: MANUFACTURING PROCESSES

Course Objectives:

- To understand the fundamental principles of various manufacturing processes used in industry.
- To analyse the working principles, applications, and limitations of different manufacturing methods.
- To develop knowledge of material removal, forming, joining, and additive manufacturing techniques.
- To prepare students for selecting appropriate manufacturing processes for given engineering components.
- To provide insight into modern manufacturing trends including automation, Industry 4.0, and sustainable manufacturing.

Course Outcomes: At the end of the course students shall be able to

CO1	Classify and explain different conventional manufacturing processes.
CO2	Select appropriate machining processes based on material, geometry, and precision requirements.
C03	Analyze metal forming, joining, and casting processes for component fabrication.
C04	Evaluate modern manufacturing techniques including CNC, additive manufacturing, and non-traditional methods.

Unit	Content	Credit	Weightage
I	METAL CASTING PROCESSES Introduction to Manufacturing, Pattern Making, Molding Materials & Methods, Casting Processes, Casting Defects & Inspection, Melting & Pouring	1	25%
II	METAL FORMING & JOINING PROCESSES Metal Forming Fundamentals, Bulk Forming Processes, Sheet Metal Working, Joining Processes Powder Metallurgy, Forming Defects & Quality	1	25%
III	MACHINING & MATERIAL REMOVAL PROCESSES Theory of Metal Cutting, Cutting Tool Materials, Traditional Machining Processes, Machining Parameters,	1	25%

	Machine Tools, Cutting Fluids		
IV	MODERN & NON-TRADITIONAL MANUFACTURING Non-Traditional Machining Processes, CNC Machining, Additive Manufacturing, Surface Finishing Processes, Manufacturing Automation, Sustainable Manufacturing	1	25%

Textbooks:

- Manufacturing Technology: Foundry, Forming and Welding – P.N. Rao (McGraw Hill)
- Production Technology – R.K. Jain (Khanna Publishers)
- Manufacturing Processes for Engineering Materials – Serope Kalpakjian and Steven Schmid (Pearson)
- A Textbook of Manufacturing Technology – R.K. Rajput (Laxmi Publications)

Reference books:

- Fundamentals of Modern Manufacturing – Mikell P. Groover (Wiley)
- Manufacturing Science – Amitabha Ghosh and Asok Kumar Mallik (Affiliated East-West Press)
- Principles of Manufacturing Materials & Processes – James S. Campbell (McGraw Hill)
- Advanced Machining Processes – V.K. Jain (Allied Publishers)
- Additive Manufacturing Technologies – Ian Gibson, David Rosen, Brent Stucker (Springer)

Online Platforms:

NPTEL Courses:

- "Manufacturing Processes I" by Prof. S.K. Pal (IIT Kharagpur)
- "Advanced Manufacturing Processes" by IIT Roorkee

SUBJECT CODE: BTME304

SUBJECT NAME: STRENGTH OF MATERIALS

Course Objectives:

- To understand the behaviour of materials under various types of loading (tension, compression, bending, torsion, and shear).
- To analyse stresses, strains, and deformations in mechanical components and structures.
- To study the theories of failure and apply them to design safe mechanical components.
- To determine deflections in beams and analyse columns under buckling conditions.
- To prepare students for advanced courses in machine design, structural analysis, and finite element analysis.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze stresses and strains in mechanical components under axial, shear, and torsional loads.
CO2	Determine shear force, bending moment, and stresses in beams under different loading conditions.
C03	Calculate deflections in beams using various methods and analyze columns for buckling.
C04	Apply theories of failure to predict yielding and fracture in ductile and brittle materials.

Unit	Content	Credit	Weightage

I	SIMPLE STRESSES AND STRAINS Introduction to Solid Mechanics, Axial Loading, Shear Stress and Strain, Mechanical Properties, Composite Sections, Strain Energy	1	25%
II	BEAMS - SHEAR FORCE AND BENDING MOMENT Types of Beams and Loads, Shear Force and Bending Moment, SFD and BMD, Shear Stresses in Beams	1	25%
III	DEFLECTION OF BEAMS AND TORSION Deflection of Beams, Methods for Deflection Calculation, Torsion of Circular Shafts, Torsion in Composite and Hollow Shafts, Springs	1	25%
IV	COLUMNS, ENERGY METHODS, AND THEORIES OF FAILURE Columns and Struts, Energy Methods, Theories of Failure, Combined Stresses, Unsymmetrical Bending	1	25%

Textbooks:

- Strength of Materials – R.K. Bansal (Laxmi Publications)
- Mechanics of Materials – James M. Gere and Barry J. Goodno (Cengage Learning)
- Strength of Materials – S.S. Rattan (McGraw Hill)
- Strength of Materials – R. Subramanian (Oxford University Press)

Reference books:

- Advanced Mechanics of Materials – Arthur P. Boresi and Richard J. Schmidt (Wiley)
- Strength of Materials – S. Timoshenko (CBS Publishers)
- Engineering Mechanics of Solids – Egor P. Popov (Pearson)
- Mechanics of Materials – Ferdinand P. Beer, E. Russell Johnston, Jr., John T. DeWolf (McGraw Hill)
- Strength of Materials – D.S. Prakash Rao (University Press)

Online Platforms:

NPTEL Courses:

1. "Strength of Materials" by Prof. S. K. Maiti (IIT Bombay)
2. "Mechanics of Solids" by IIT Madras

SUBJECT CODE: BTME305

SUBJECT NAME: BASIC ELECTRONICS AND INSTRUMENTATION

Course Objectives:

- To introduce fundamental electronic components, circuits, and their applications in mechanical systems.
- To develop understanding of sensors, transducers, and measurement techniques for mechanical parameters.
- To familiarize students with signal conditioning, data acquisition, and control systems relevant to mechanical engineering.
- To enable integration of electronic systems with mechanical systems for automation and smart applications.
- To prepare mechanical engineers for interdisciplinary roles in mechatronics, IoT, and industrial automation.

Course Outcomes: At the end of the course students shall be able to

CO1	Identify and analyze basic electronic components and circuits.
CO2	Select appropriate sensors and transducers for mechanical parameter measurement.

C03	Design and implement basic signal conditioning and data acquisition systems.
C04	Interface sensors with microcontrollers/PLC for automation applications.

Unit	Content	Credit	Weightage
I	FUNDAMENTAL ELECTRONICS & SEMICONDUCTOR DEVICES Introduction to Electronics, Passive Components, Semiconductor Physics, Transistors, Operational Amplifiers, Digital Electronics Basics	1	35%
II	SENSORS, TRANSDUCERS & MEASUREMENT SYSTEMS Measurement Fundamentals, Sensors for Mechanical Parameters, Signal Conditioning, Data Acquisition Systems	1	35%
III	INSTRUMENTATION SYSTEMS & CONTROL APPLICATIONS Display & Recording Devices, Programmable Logic Controllers (PLCs), Industrial Communication Protocols, Case Studies, Emerging Trends	1	30%

Textbooks:

- Electronic Devices and Circuits – R.L. Boylestad and L. Nashelsky (Pearson)
- Principles of Industrial Instrumentation – D. Patranabis (McGraw Hill)
- Sensors and Transducers – D. Patranabis (PHI Learning)
- A Textbook of Electrical Technology – B.L. Theraja and A.K. Theraja (S. Chand)

Reference books:

- Op-Amps and Linear Integrated Circuits – R.A. Gayakwad (Pearson)
- Measurement Systems: Application and Design – E.O. Doebelin (McGraw Hill)
- Introduction to Mechatronics and Measurement Systems – David G. Alciatore and Michael B. Histand (McGraw Hill)
- Industrial Instrumentation and Control – S.K. Singh (McGraw Hill)
- Arduino for Beginners – John Baichtal (Pearson)

Online Platforms:

NPTEL Courses:

- "Industrial Instrumentation" by IIT Roorkee
- "Basic Electronics" by IIT Madras

PRACTICALS LIST (ANY 08):

- Exp 1: Familiarization with electronic components and measuring instruments (DMM, oscilloscope, function generator).
- Exp 2: Study of diode characteristics and design of half-wave/full-wave rectifier with filter.
- Exp 3: Transistor characteristics (CE configuration) and design of simple amplifier.
- Exp 4: Operational amplifier circuits – inverting and non-inverting amplifier.
- Exp 5: Temperature measurement using thermocouple/RTD and signal conditioning.
- Exp 6: Displacement measurement using LVDT/potentiometer.
- Exp 7: Strain gauge-based load cell for force measurement.
- Exp 8: Vibration measurement using piezoelectric accelerometer.

- Exp 9: Data acquisition system – interfacing sensors with Arduino/DAQ card.
- Exp 10: PID control of temperature using Arduino/LabVIEW.
- Exp 11: PLC programming for motor control (start-stop, forward-reverse).
- Exp 12: Mini-project: Design of a simple measurement system (e.g., digital thermometer, tachometer).

SUBJECT CODE: BTME306

SUBJECT NAME: CAD LAB (SOLID WORKS/ AUTO CAD)

Course Objectives:

- To develop proficiency in using CAD software for 2D drafting and 3D modelling.
- To create, edit, and dimension engineering drawings using standard conventions.
- To design and assemble mechanical components using parametric modelling techniques.
- To generate production-ready drawings, bill of materials, and assembly layouts.
- To prepare students for industry-standard CAD practices and certification.

Course Outcomes: At the end of the course students shall be able to

CO1	Create 2D engineering drawings with proper dimensioning and annotations in AutoCAD.
CO2	Develop 3D solid models of mechanical components using SolidWorks.
C03	Assemble multiple parts, check for interference, and create exploded views.
C04	Generate production drawings, bill of materials, and sheet layouts.

Reference books:

- AutoCAD 2024: A Problem-Solving Approach – Sham Tickoo (CADCIM)
- SolidWorks 2024 for Designers – Prof. Sham Tickoo (CADCIM)
- Engineering Design with SolidWorks – David Planchard (SDC Publications)
- AutoCAD and Its Applications Basics – Terence M. Shumaker (Goodheart-Willcox)

PRACTICALS LIST (12 Sessions):

PART I: AutoCAD – 2D Drafting (Sessions 1–4)

1. **Session 1: Introduction to AutoCAD & Basic Drawing Commands**
   - AutoCAD interface, workspace setup, coordinate systems.
   - Drawing commands: Line, Circle, Arc, Rectangle, Polygon.
   - Editing commands: Trim, Extend, Offset, Mirror, Array.
   - **Exercise:** Draw a simple mechanical bracket with dimensions.
2. **Session 2: Dimensioning & Annotations**
   - Dimension styles, linear, angular, radial, diameter dimensions.
   - Text styles, multiline text, leaders.
   - Hatching, layers, and properties.
   - **Exercise:** Create a fully dimensioned drawing of a flange coupling.
3. **Session 3: Orthographic Projections**
   - First-angle vs third-angle projections.

  - Creating front, top, and side views from isometric sketches.
  - Adding sectional views.
  - **Exercise:** Draw orthographic views of a machine component with section.

4. **Session 4: Advanced 2D Drafting & Plotting**
  - Blocks, attributes, dynamic blocks.
  - Title block creation, sheet setup, layout management.
  - Plotting to scale, PDF export.
  - **Exercise:** Prepare a drawing sheet with title block and multiple views.

PART II: SolidWorks – 3D Modeling (Sessions 5–9)

5. **Session 5: Introduction to SolidWorks & Sketching**
  - SolidWorks interface, sketch plane, relations, dimensions.
  - Sketch tools: Line, Circle, Arc, Spline, Rectangle, Fillet, Chamfer.
  - Extrude and Revolve features.
  - **Exercise:** Create a simple 3D part (e.g., shaft, bracket).
6. **Session 6: Advanced Features & Pattern**
  - Sweep, Loft, Draft, Shell, Rib.
  - Linear and circular pattern, mirror feature.
  - Reference geometry: planes, axes, points.
  - **Exercise:** Model a helical spring or a mechanical housing.
7. **Session 7: Assembly Design**
  - Creating assemblies, inserting components.
  - Standard mates: Coincident, Parallel, Perpendicular, Tangent.
  - Advanced mates: Gear, Cam, Screw.
  - **Exercise:** Assemble a simple ball bearing or pillow block.
8. **Session 8: Drawing Generation from 3D Models**
  - Creating drawing from part/assembly.
  - Standard views, section views, detail views.
  - Adding annotations, GD&T symbols.
  - **Exercise:** Generate a multi-view drawing of an assembled component.
9. **Session 9: Advanced Assembly & Motion Study**
  - Exploded views, bill of materials (BOM).
  - Interference detection, collision detection.
  - Basic motion study (animation).
  - **Exercise:** Create exploded view with BOM for a gear assembly.

PART III: Integrated Project & Applications (Sessions 10–12)

10. **Session 10: CAD Project – Part Modelling**
  - Design a mechanical component (e.g., piston, connecting rod, valve body).
  - Apply advanced features: threads, fillets, chamfers, patterns.
  - **Deliverable:** 3D model with proper design intent.
11. **Session 11: CAD Project – Assembly Creation**
  - Create assembly of designed components (e.g., IC engine parts, pump assembly).
  - Apply appropriate mates, check for interference.
  - **Deliverable:** Fully constrained assembly.
12. **Session 12: Project Documentation & Presentation**

  - Generate detailed drawing sheets with BOM.
  - Create presentation views, exploded animations.
  - **Deliverable:** Complete project report with all CAD files.

SOFTWARE & TOOLS:

- **AutoCAD 2024** (or latest version)
- **SolidWorks 2024** (or latest version)
- **PDF Printer** (for drawing submission)
- **Lab Computers** with required specifications

SEMESTER-IV

SUBJECT CODE: BTME401

SUBJECT NAME: HEAT TRANSFER

Course Objectives:

- Derive and solve governing equations for conduction, convection, and radiation.
- Select appropriate correlations for convection problems.
- Design and analyse heat exchangers using LMTD/NTU methods.
- Solve combined-mode heat transfer problems.
- Use computational tools for basic thermal analysis.

Course Outcomes: At the end of the course students shall be able to

CO1	Introduce fundamental modes of heat transfer: conduction, convection, and radiation.
CO2	Develop analytical and empirical tools to solve engineering heat transfer problems.
C03	Apply principles to design and evaluate thermal systems (heat exchangers, fins, insulation, etc.).
C04	Prepare students for advanced courses and real-world applications in thermal engineering.

Unit	Content	Credit	Weightage
I	**Introduction and Conduction** • Modes of heat transfer: conduction, convection, radiation. • Fourier's law, thermal conductivity, thermal diffusivity. • General heat conduction equation in Cartesian, cylindrical, and spherical coordinates. • Steady-state 1D conduction: plane wall, cylinder, sphere, composite layers. • Thermal resistance networks.	1	25%
II	**Convection – Fundamentals and External Flow** • Convection mechanisms: forced and natural convection. • Boundary layer concepts: velocity and thermal boundary layers. • Dimensionless numbers: Re, Pr, Nu, Gr, Ra. • Governing equations (continuity, momentum, energy) – brief overview. • External flow over flat plates, cylinders, spheres. • Empirical correlations for Nu. • Flow across tube banks. • Internal flow: Hydrodynamic and thermal entry lengths. • Constant heat flux vs. constant wall temperature conditions. • Empirical correlations for laminar and turbulent pipe	1	25%

	flow.		
III	**Internal Flow, Natural Convection, and Boiling/Condensation** • Internal flow correlations (Dittus-Boelter, Gnielinski, etc.). • Natural convection: vertical/horizontal plates, cylinders, enclosures. • Correlations for Nu in natural convection. • Combined forced and natural convection. • Phase-change heat transfer	1	25%
IV	**Radiation and Applications** • Thermal radiation fundamentals: blackbody, emissive power, Planck's law, Wein's & Stefan-Boltzmann laws. • Radiation properties: emissivity, absorptivity, reflectivity, transmissivity. • Kirchhoff's law, gray surfaces. • View factor: definition, properties, determination (algebraic, charts). • Radiation exchange between black surfaces. • Radiation shields. • Radiation in enclosures with gray diffuse surfaces (network method). • Combined modes: conduction-convection-radiation problems. • Introduction to heat transfer in manufacturing/energy systems (optional case studies).	1	25%

Textbooks:

- Incropera, F. P., DeWitt, D. P., Bergman, T. L., & Lavine, A. S., *Fundamentals of Heat and Mass Transfer*, 8th Ed., Wiley.
- Cengel, Y. A., & Ghajar, A. J., *Heat and Mass Transfer: Fundamentals & Applications*, 6th Ed., McGraw-Hill.

Reference books:

- Holman, J. P., *Heat Transfer*, 10th Ed., McGraw-Hill.
- Kreith, F., Manglik, R. M., & Bohn, M. S., *Principles of Heat Transfer*, 8th Ed., Cengage.
- Mills, A. F., *Heat Transfer*, 2nd Ed., Prentice Hall.
- Bergman, T. L., Lavine, A. S., Incropera, F. P., & DeWitt, D. P., *Incropera's Principles of Heat and Mass Transfer*, Global Ed., Wiley.

Online Platforms:

- NPTEL Lectures 36–45
- MIT OCW: Radiation Heat Transfer
- Coursera Week 5–6 (Radiation)
- NPTEL (India) – Heat Transfer – Prof. S. K. Som (IIT Kharagpur) / Prof. C. Balaji (IIT Madras)

SUBJECT CODE: BTME402

SUBJECT NAME: MACHINE DESIGN-I

Course Objectives:

- Introduce fundamental principles of mechanical design: static and fatigue failure theories, stress concentration, and factor of safety.
- Develop skills in designing and analysing machine components under various loading conditions.
- Apply design principles to real-world mechanical elements such as shafts, fasteners, springs, and joints.
- Prepare students for advanced machine design courses and practical engineering applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply failure theories to design components under static and fatigue loading.
CO2	Design shafts, keys, and couplings for power transmission systems.
C03	Analyze and design bolted, riveted, and welded joints.
C04	Design helical springs for specified load-deflection requirements.

Unit	Content	Credit	Weightage
I	**Fundamentals of Mechanical Design** • Introduction to design process: need analysis, synthesis, evaluation. • Materials selection in design: mechanical properties, standards. • Static failure theories: Maximum Normal Stress, Maximum Shear Stress (Tresca), Distortion Energy (von Mises), Coulomb-Mohr. • Stress concentration factors: theoretical vs. fatigue stress concentration. • Factor of safety: deterministic vs. probabilistic approaches. • Introduction to fatigue failure: S-N curves, endurance limit, modifying factors. • Fluctuating stresses: Goodman, Gerber, and Soderberg criteria.	1	25%
II	**Design of Shafts, Keys, and Couplings** • Shaft design under static and fatigue loading. • ASME shaft design code. • Stress analysis in shafts with keyways, grooves, and fillets. • Design of keys (saddle, sunk, feather, woodruff) and splines. • Rigid and flexible couplings: muff, flange, bush-pin, Oldham, universal joints. • Critical speed of shafts (introductory). • Design projects: transmission shaft for given torque/power.	1	25%
III	**Design of Fasteners and Permanent Joints**	1	25%

	• Thread terminology, standards, stress areas. • Bolted joints under tension and shear: preload, external loads, gasketed joints. • Eccentric loading on bolted joints: primary & secondary shear. • Design of bolted joints for static and fatigue loading. • Riveted joints: types, failure modes, efficiency calculations. • Welded joints: butt and fillet welds, stress analysis under axial, bending, and torsional loads. • Introduction to adhesive bonding.		
IV	**Design of Springs and Mechanical Drives (Intro)** • Types of springs: helical compression/tension, torsion, leaf springs. • Stress and deflection in helical springs: Wahl factor, spring rate. • Spring design for static and fatigue loading, buckling considerations. • Energy storage capacity. • Introduction to belt drives: flat and V-belts, selection from manufacturer's catalogue. • Introduction to chain drives: roller chains, polygonal effect. • Gear drives (intro only – detailed in Machine Design II).	1	25%

Textbooks:

- Shigley, J. E., Mischke, C. R., & Brown, T. H., *Shigley's Mechanical Engineering Design*, 11th Ed., McGraw-Hill.
- Spotts, M. F., Shoup, T. E., Hornberger, L. E., & Riber, J. C., *Design of Machine Elements*, 8th Ed., Pearson.

Reference books:

- Norton, R. L., *Machine Design: An Integrated Approach*, 5th Ed., Pearson.
- Budynas, R. G., & Nisbett, J. K., *Shigley's Mechanical Engineering Design*, SI Version, 10th Ed., McGraw-Hill.
- Bhandari, V. B., *Design of Machine Elements*, 4th Ed., McGraw-Hill.
- Juvinall, R. C., & Marshek, K. M., *Fundamentals of Machine Component Design*, 7th Ed., Wiley.

Online Platforms:

- NPTEL (India) – Machine Design I – Prof. G. Chakraborty (IIT Kharagpur) / Prof. B. Maiti (IIT Guwahati)

SUBJECT CODE: BTME404

SUBJECT NAME: METROLOGY AND MEASUREMENT

Course Objectives:

- Introduce fundamental concepts of measurement, standards, and units.
- Familiarize students with precision measuring instruments and their applications.
- Understand principles of geometric dimensioning and tolerancing (GD&T), and limits/fits.
- Develop skills in measurement uncertainty analysis and calibration procedures.
- Apply measurement techniques in quality control and manufacturing.

Course Outcomes: At the end of the course students shall be able to

CO1	Select appropriate instruments for linear, angular, and surface measurements.
CO2	Interpret engineering drawings with GD&T symbols.
C03	Perform calibration and uncertainty analysis for measurements.
C04	Operate basic metrology equipment (CMM, profilometer, comparators).

Unit	Content	Credit	Weightage
I	**Fundamentals of Metrology and Linear/Angular Measurement** • Introduction: need, objectives, applications of metrology. • Standards: line, end, wavelength standards, classification (primary, secondary, etc.). • Measurement systems: elements, errors (systematic, random), uncertainty analysis (type A & B). • Linear measurement: Vernier caliper, micrometer, slip gauges (wringing, building of sets). • Angular measurement: bevel protractor, sine bar, spirit level, angle gauges. • Comparators: mechanical, optical, pneumatic, and electronic types. • Limit gauges: Taylor’s principle, plug, ring, snap gauges.	1	35%
II	**Advanced Dimensional Metrology and GD&T** • Limits, fits, and tolerances: ISO system, hole and shaft basis, selection. • Geometric Dimensioning and Tolerancing (GD&T): symbols, datums, form (straightness, flatness, circularity, cylindricity), orientation (parallelism, perpendicularity, angularity), location (position, concentricity, symmetry). • Surface roughness: parameters (Ra, Rz, Rq), measurement methods (profilometer, comparator). • Coordinate Measuring Machine (CMM): types, probes, programming, applications. • Laser interferometry, toolmaker’s microscope, optical projector.	1	35%

III	**Mechanical and Miscellaneous Measurements** • Measurement of force: load cells, proving rings, strain gauges. • Torque measurement: dynamometers (absorption, transmission type). • Pressure measurement: manometers, Bourdon tube, diaphragm gauges. • Temperature measurement: thermocouples, RTD, thermistors, pyrometers. • Flow measurement: orifice, venturi, rotameter. • Strain measurement: electrical strain gauges, bridge circuits. • Introduction to non-destructive testing (NDT): dye penetrant, ultrasonic, radiographic (basic principles). • Calibration: concept, traceability, calibration intervals.	1	30%

Textbooks:

- Jain, R. K., *Engineering Metrology*, 20th Ed., Khanna Publishers.
- Beckwith, T. G., Marangoni, R. D., & Lienhard, J. H., *Mechanical Measurements*, 6th Ed., Pearson.

Reference books:

- Gupta, I. C., *A Textbook of Engineering Metrology*, 8th Ed., Dhanpat Rai & Co.
- Doebelin, E. O., & Manik, D. N., *Measurement Systems: Application and Design*, 6th Ed., McGraw-Hill.
- Galyer, J. F. W., & Shotbolt, C. R., *Metrology for Engineers*, 5th Ed., Cengage.
- ASTM Standards – Relevant sections on dimensional and mechanical measurements.

Online Platforms:

- NPTEL – Metrology – Prof. R. K. Garg (IIT Roorkee) / Prof. N. K. Mehta (IIT Roorkee)

Practical List:

- Measurement using Vernier caliper and micrometer – Accuracy, repeatability.
- Use of slip gauges – Building of various dimensions, calibration of micrometer.
- Angle measurement using sine bar – Setting angles, use of slip gauges.
- Surface roughness measurement – Using profilometer (Ra, Rz).
- Gear measurement – Gear tooth vernier (span measurement), profile projector.
- Thread measurement – Two-wire method, thread plug gauges.
- Calibration of pressure gauge – Using dead weight tester.
- Temperature measurement – Using thermocouple/RTD with indicator.
- Force measurement – Using load cell/strain gauge setup.
- Use of optical comparator – Profile measurement of a component.
- Demonstration of Coordinate Measuring Machine (CMM) – Measurement of prismatic part.
- Tolerance stack-up analysis – Manual calculation for an assembly.

SUBJECT CODE: BTME405

SUBJECT NAME: INDUSTRIAL MANAGEMENT

Course Objectives:

- Introduce fundamental principles of industrial management, organizational structures, and managerial functions.
- Develop skills in production planning, inventory control, quality management, and cost analysis.
- Apply quantitative techniques for decision-making in resource allocation, scheduling, and productivity improvement.
- Prepare students for roles in industrial engineering, operations management, and entrepreneurship.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze and improve productivity using work-study techniques.
CO2	Apply forecasting and inventory models for production planning.
C03	Implement basic quality control tools and SQC techniques.
C04	Develop project schedules using CPM/PERT.

Unit	Content	Credit	Weightage
I	**Module 1: Foundations of Industrial Management** • Introduction: evolution of industrial engineering, productivity, competitiveness. • Management functions: planning, organizing, staffing, directing, controlling. • Organizational structures: line, staff, functional, matrix, project-based. • Plant location and layout: factors, types (product, process, fixed position, cellular). • Work study: method study and time study (stopwatch, work sampling). • Ergonomics and human factors engineering. • Cost concepts: fixed, variable, marginal, break-even analysis.	1	30%
II	**Production Planning and Inventory Control** • Production systems: job shop, batch, mass, continuous. • Forecasting techniques: qualitative and quantitative (moving average, exponential smoothing, regression). • Aggregate production planning: strategies (chase, level, mixed). • Inventory management: EOQ models (basic, with shortages, quantity discounts), ABC analysis, VED classification. • Material Requirements Planning (MRP-I): bill of materials, master production schedule. • Just-in-Time (JIT) and Lean manufacturing: Kanban, 5S, waste elimination.	1	35%

	• Introduction to Enterprise Resource Planning (ERP).		
III	**Quality Management and Project Management** • Quality concepts: evolution, cost of quality, TQM principles. • Statistical quality control: control charts ($\bar{X}$-R, p, c charts), process capability (Cp, Cpk). • Six Sigma: DMAIC methodology, roles (Green Belt, Black Belt). • ISO 9000 series: standards, certification process. • Project management: network diagrams (CPM, PERT), critical path, crashing. • Resource levelling and allocation. • Introduction to Industry 4.0: IoT, smart manufacturing, digital twins.	1	35%

Textbooks:

- Martand Telsang, *Industrial Engineering and Production Management*, 2nd Ed., S. Chand Publishing.
- Buffa, E. S., & Sarin, R. K., *Modern Production/Operations Management*, 8th Ed., Wiley.

Reference books:

- Chary, S. N., *Production and Operations Management*, 6th Ed., McGraw-Hill.
- Mahajan, M., *Industrial Engineering and Management*, 3rd Ed., Khanna Publishers.
- Krajewski, L. J., Ritzman, L. P., & Malhotra, M. K., *Operations Management: Processes and Supply Chains*, 12th Ed., Pearson.
- Stevenson, W. J., *Operations Management*, 14th Ed., McGraw-Hill.

Online Platforms:

- NPTEL – Industrial Engineering – Prof. R. K. Garg (IIT Roorkee) / Prof. A. Subash Babu (IIT Bombay)

SUBJECT CODE: BTME406

SUBJECT NAME: CNC PROGRAMMING LAB

Course Objectives:

- To introduce the fundamentals of CNC machine tools, their components, and coordinate systems.
- To develop skills in manual part programming (G-codes, M-codes) for milling and turning operations.
- To provide hands-on experience in CNC simulation software and actual machine operation.
- To integrate CAD/CAM for generating CNC programs and verifying toolpaths.
- To produce simple to complex components adhering to engineering specifications and safety standards.

Course Outcomes: At the end of the course students shall be able to

CO1	Understand CNC machine architecture and coordinate systems.
CO2	Write, debug, and optimize manual part programs for turning and milling.
C03	Generate CNC programs using CAD/CAM software and verify toolpaths.
C04	Safely operate CNC machines for producing components within tolerances.

Practical List

Part A: CNC Fundamentals & Simulation

Experiment 1: Introduction to CNC Machines

- Study of CNC machine components: control panel, axes, spindle, tool turret, coolant system.
- Understanding machine coordinate system (MCS) and workpiece coordinate system (WCS).
- Demonstration of machine homing, tool change, and work offset setting.

Experiment 2: CNC Programming Basics

- Structure of a CNC program: program number, blocks, word address format.
- Study of G-codes (preparatory functions) and M-codes (miscellaneous functions).
- Writing a simple program for linear and circular interpolation (using simulation software).

Experiment 3: CNC Turning Simulation

- Writing a program for facing, turning, tapering, and grooving on a CNC lathe.
- Use of canned cycles (G71, G72, G76) for roughing and threading.
- Simulation and verification of toolpath.

Experiment 4: CNC Milling Simulation

- Writing a program for pocket milling, profile milling, and drilling operations.
- Use of cutter radius compensation (G40, G41, G42) and fixed cycles (G81, G83).
- Simulation and debugging of errors.

Part B: CAD/CAM Programming

Experiment 5: Introduction to CAD/CAM Software

- Importing/creating a 2D drawing (e.g., a bracket or flange) in CAD software.
- Defining stock, selecting tools, setting machining parameters (speed, feed, depth of cut).

Experiment 6: CAM Toolpath Generation

- Generating toolpaths for contouring, pocketing, and drilling.
- Post-processing to generate machine-specific G-code (for FANUC, Siemens, or Heidenhain controllers).

Experiment 7: Simulation and Verification

- Using CAM software to simulate machining, detect collisions, and verify final part geometry.
- Editing G-code for optimization (reducing air time, optimizing tool changes).

Experiment 8: Integration Project

- Design a simple component (e.g., a nameplate or chess pawn) in CAD.
- Generate CAM program, simulate, and post-process for a specific CNC machine.

Part C: Hands-on Machining

Experiment 9: CNC Machine Setup

- Power-up and homing procedure.
- Workpiece clamping (using vise, fixtures).
- Tool setting (using touch probe or manual edge finder).
- Setting work offsets (G54–G59).

Experiment 10: Machining a Turning Component

- Mounting raw material (aluminum/ mild steel rod) in chuck.
- Loading, editing, and running a turning program.
- In-process measurements using calipers/micrometers.
- Producing a stepped shaft with threads and grooves.

Experiment 11: Machining a Milling Component

- Mounting a rectangular block (wax, aluminum, or plastic).
- Running a milling program for pocketing and profiling.
- Use of multiple tools and tool length compensation.
- Producing a part with slots, holes, and contours.

Experiment 12: Final Project – Design to Product

- Design a functional component (e.g., a small vise jaw, tool holder, or puzzle cube part).
- Complete process: CAD → CAM → Simulation → Machining → Inspection.
- Documentation of process plan, program, and quality check report.

SEMESTER-V

SUBJECT CODE: BTME501

SUBJECT NAME: INTERNAL COMBUSTION ENGINES

Course Objectives:

- Introduce fundamental principles of internal combustion engines, their classification, and operational cycles.
- Analyse engine processes: air-standard cycles, fuel-air cycles, and actual cycles.
- Understand engine subsystems: fuel injection, ignition, combustion, cooling, lubrication, and emissions control.
- Evaluate engine performance parameters, testing methods, and emerging technologies (alternate fuels, hybrid systems).

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze IC engine cycles and calculate performance parameters.
CO2	Compare combustion phenomena in SI and CI engines and explain fuel injection/ignition systems.
C03	Evaluate engine subsystems (turbocharging, cooling, lubrication, emission control).
C04	Interpret engine performance maps and emission characteristics.

Unit	Content	Credit	Weightage
I	**Introduction and Thermodynamic Cycles** • Introduction: Classification of IC engines (SI, CI, 2-stroke, 4-stroke), engine components and nomenclature. • Air-standard cycles: Otto, Diesel, Dual, Comparison of cycles, fuel-air cycles, actual cycles. • Engine performance parameters: indicated power, brake power, friction power, thermal efficiencies, specific fuel consumption. • Engine testing: dynamometers, performance maps, heat balance sheet.	1	25%
II	**Fuel Systems, Combustion, and Ignition** • Fuels: properties of SI and CI engine fuels, alternate fuels (CNG, LPG, hydrogen, biofuels). • Carburetion and fuel injection systems (SI engines): MPFI, GDI, components. • Fuel injection in CI engines: pump-line-nozzle systems, common rail direct injection (CRDi). • Combustion in SI engines: stages, flame propagation, abnormal combustion (knock, surface ignition), octane rating. • Combustion in CI engines: stages, delay period, diesel knock, cetane rating. • Ignition systems: battery, magneto, electronic ignition, spark plugs.	1	25%

III	**Engine Subsystems and Cooling/Lubrication** • Supercharging and turbocharging: methods, intercooling, wastegate, turbo lag. • Engine cooling systems: air-cooling, water-cooling, thermostats, radiators. • Lubrication systems: types (mist, splash, pressure), lubricating oils, additives, oil pumps, filters. • Engine emissions: formation of CO, HC, NOx, particulate matter (PM), smoke. • Emission control techniques: catalytic converters (three-way), EGR, SCR, DPF.	1	25%
IV	**Engine Design, Testing, and Advanced Concepts** • Engine design considerations: bore-stroke ratio, compression ratio, valve timing diagrams, port design. • Engine testing and performance characteristics: torque-speed curves, fuel consumption maps, emission maps. • Alternative engine types: Wankel rotary engine, stratified charge engines, HCCI. • Hybrid electric vehicles: series, parallel, and series-parallel hybrids, regenerative braking. • Future trends: electric vehicles, fuel cells, hydrogen IC engines, sustainable mobility.	1	25%

Textbooks:

- Ganesan, V., *Internal Combustion Engines*, 5th Ed., McGraw-Hill.
- Heywood, J. B., *Internal Combustion Engine Fundamentals*, 2nd Ed., McGraw-Hill.

Reference books:

- Mathur, M. L., & Sharma, R. P., *Internal Combustion Engines*, 11th Ed., Dhanpat Rai.
- Pulkrabek, W. W., *Engineering Fundamentals of the Internal Combustion Engine*, 2nd Ed., Pearson.
- Stone, R., *Introduction to Internal Combustion Engines*, 4th Ed., Palgrave Macmillan.
- Taylor, C. F., *The Internal Combustion Engine in Theory and Practice* (Vol. 1 & 2), MIT Press.

Online Platforms:

- NPTEL – Internal Combustion Engines – Prof. M. K. G. Babu (IIT Madras) / Prof. A. Ramesh (IIT Madras)

SUBJECT CODE: BTME502

SUBJECT NAME: REFRIGERATION AND AIR CONDITIONING

Course Objectives:

- To introduce the fundamental principles and methods of refrigeration and air conditioning.
- To analyse vapor compression and absorption refrigeration cycles and their components.
- To understand psychrometric processes, air conditioning systems, and load estimation.
- To study refrigerants, environmental impacts, and emerging sustainable cooling technologies.
- To provide hands-on experience in system design, analysis, and performance evaluation.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze vapor compression and absorption refrigeration cycles using P-h/T-s charts.
CO2	Select appropriate refrigerants and components for given applications.
C03	Perform psychrometric calculations and cooling load estimations.
C04	Design basic air conditioning systems and duct layouts.

Unit	Content	Credit	Weightage
I	**Fundamentals of Refrigeration** • Introduction: methods of refrigeration (vapor compression, absorption, thermoelectric, vortex tube). • Reversed Carnot cycle and limitations. • Vapor compression refrigeration cycle: P-h and T-s diagrams, subcooling, superheating. • Refrigeration effect, compressor work, COP, efficiency. • Multistage and cascade systems – applications. • Refrigerants: classification, properties (ODP, GWP), selection, environmental regulations (Montreal/Kyoto Protocols).	1	25%
II	**Refrigeration System Components and Accessories** • Compressors: reciprocating, rotary, screw, scroll, centrifugal – working and performance. • Condensers: air-cooled, water-cooled, evaporative – design considerations. • Evaporators: DX, flooded, finned-tube – applications. • Expansion devices: capillary tube, thermostatic expansion valve (TXV), float valves. • System accessories: receivers, driers, sight glass, oil separators, solenoid valves. • Heat exchangers: suction line heat exchangers, sub coolers. • Introduction to absorption refrigeration: LiBr-H_2O and NH_3-H_2O systems.	1	25%
III	**Psychrometrics and Air Conditioning** • Psychrometric properties: DBT, WBT, DPT, humidity ratio, specific volume, enthalpy. • Psychrometric chart: plotting processes (sensible heating/cooling, humidification, dehumidification, mixing). • Human comfort: effective temperature, comfort charts, indoor air quality (IAQ). • Cooling load estimation: heat gain through walls, windows, infiltration, occupants, appliances. • CLTD/CLF method (simplified approach). • Types of air conditioning systems: window, split, packaged, central (all-air, air-water), VRF systems.	1	25%

IV	**AC Systems Design, Controls, and Emerging Trends** • Duct design: types, sizing methods (equal friction, velocity reduction), air distribution. • Controls: thermostats, humidistats, VAV systems, BMS introduction. • Energy conservation in HVAC: heat recovery systems, economizers, inverter technology. • Solar refrigeration and air conditioning: absorption, desiccant cooling. • Green buildings: LEED certification, HVAC role. • Cold storage and food preservation: insulation, refrigeration requirements. • Introduction to electric vehicle thermal management.	1	25%

Textbooks:

- Arora, C. P., *Refrigeration and Air Conditioning*, 4th Ed., McGraw-Hill.
- Stoecker, W. F., & Jones, J. W., *Refrigeration and Air Conditioning*, 2nd Ed., McGraw-Hill.

Reference books:

- Manohar Prasad, *Refrigeration and Air Conditioning*, 3rd Ed., New Age International.
- Dossat, R. J., & Horan, T. J., *Principles of Refrigeration*, 5th Ed., Pearson.
- ASHRAE Handbook – Fundamentals & HVAC Applications.
- Shan K. Wang – *Handbook of Air Conditioning and Refrigeration*, 2nd Ed., McGraw-Hill.

Online Platforms:

- NPTEL – Refrigeration and Air Conditioning – Prof. R. C. Arora (IIT Kharagpur) / Prof. M. Ramgopal (IIT Kharagpur)

SUBJECT CODE: BTME503

SUBJECT NAME: MACHINE DESIGN-II

Course Objectives:

- To apply advanced design principles to critical machine components such as bearings, brakes, clutches, and gears.
- To design and analyse power transmission elements including belts, chains, and gearboxes.
- To introduce design for manufacturability, reliability, and safety factors under dynamic loading.
- To integrate computational tools and standards in the design of mechanical systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Select and design bearings for specified load, speed, and life requirements.
CO2	Design brakes, clutches, and couplings for power transmission applications.
C03	Design gears and gearboxes using AGMA standards and manufacturability considerations.
C04	Integrate belts, chains, and other transmission elements into mechanical systems.

Unit	Content	Credit	Weightage
I	**Design of Bearings and Lubrication** • Types of bearings: sliding contact (journal) and	1	25%

	rolling contact (ball, roller). • Journal bearing design: hydrodynamic theory, Sommerfeld number, bearing modulus, heat dissipation. • Bearing materials and lubrication regimes (boundary, mixed, hydrodynamic). • Rolling contact bearing selection: static and dynamic load capacity, equivalent load, bearing life (L_{10}), SKF/ISO standards. • Mounting, alignment, and preloading of bearings. • Introduction to magnetic and gas bearings.		
II	**Design of Brakes, Clutches, and Couplings** • Types of brakes: block, band, internal/external shoe, disc brakes. • Design of mechanical brakes: torque capacity, heat generation, fade, wear. • Clutches: single/multi-plate, cone, centrifugal, electromagnetic. • Torque transmission, thermal analysis, and engagement dynamics. • Couplings: rigid, flexible (bushed pin, gear, Oldham, universal joints), selection criteria. • Design for safety and fail-safe operation.	1	25%
III	**Design of Gears and Gearboxes** • Gear design review: spur, helical, bevel, worm gears – force analysis, Lewis equation. • AGMA standards: bending stress (Lewis), surface durability (pitting), dynamic and wear considerations. • Gearbox design: layout, shaft arrangement, bearing selection, lubrication, housing design. • Design of parallel, planetary, and differential gear trains. • Gear manufacturing methods and inspection. • Vibration and noise reduction in gears.	1	25%
IV	**Advanced Topics and Mechanical Systems Design** • Design of belts (flat, V, timing) and chains (roller, silent): selection, power rating, center distance, tensioning. • Flexible mechanical elements: ropes, wire ropes, pulleys. • Design for fatigue under combined loading: Goodman, Soderberg, Gerber criteria. • Finite element applications in machine design: stress concentration, contact analysis. • Case studies: automotive transmission, conveyor systems, wind turbine gearbox. • Introduction to design optimization and reliability engineering.	1	25%

Textbooks:

- Shigley, J. E., Mischke, C. R., & Brown, T. H., *Shigley's Mechanical Engineering Design*,

11th Ed., McGraw-Hill.
- Norton, R. L., *Machine Design: An Integrated Approach*, 5th Ed., Pearson.

Reference books:

- Spotts, M. F., Shoup, T. E., Hornberger, L. E., & Riber, J. C., *Design of Machine Elements*, 8th Ed., Pearson.
- Juvinall, R. C., & Marshek, K. M., *Fundamentals of Machine Component Design*, 7th Ed., Wiley.
- Bhandari, V. B., *Design of Machine Elements*, 4th Ed., McGraw-Hill.
- Budynas, R. G., & Nisbett, J. K., *Shigley's Mechanical Engineering Design*, 10th Ed., McGraw-Hill.

Online Platforms:

- NPTEL – Machine Design II – Prof. G. Chakraborty (IIT Kharagpur) / Prof. B. Maiti (IIT Guwahati)

SUBJECT CODE: BTME504

SUBJECT NAME: CAD/CAM

Course Objectives:

- To introduce fundamental concepts of CAD/CAM systems and their role in modern manufacturing.
- To develop skills in 2D/3D geometric modelling, parametric design, and assembly modelling.
- To understand CNC programming, toolpath generation, and integration of CAD with CAM.
- To apply CAD/CAM tools for design analysis, simulation, and rapid prototyping.

Course Outcomes: At the end of the course students shall be able to

CO1	Create 3D parametric models and assemblies using CAD software.
CO2	Perform basic FEA and interpret results for design validation.
C03	Generate CNC toolpaths and simulate machining operations.
C04	Integrate CAD, CAE, and CAM for a complete digital manufacturing workflow.

Unit	Content	Credit	Weightage
I	**Fundamentals of CAD and Geometric Modelling** • Introduction: Role of CAD/CAM in product lifecycle, CIM, and digital manufacturing. • CAD system architecture: hardware and software components. • Geometric modelling: wireframe, surface, and solid modelling techniques. • Parametric and feature-based modelling: sketches, constraints, extrude, revolve, sweep, loft. • Assembly modelling: constraints, mating, interference checking, exploded views. • Data exchange standards: IGES, STEP, DXF, STL. • Introduction to PLM and PDM systems.	1	30%
II	**Computer-Aided Engineering (CAE) and Analysis** • Introduction to CAE: Finite Element Analysis (FEA) basics.	1	35%

	• Pre-processing: meshing, boundary conditions, material assignment. • Types of analysis: structural (stress, deformation), thermal, modal analysis. • Post-processing: interpretation of results (stress contours, deformation plots). • Optimization: topology optimization, shape optimization. • Rapid prototyping: 3D printing technologies (FDM, SLA, SLS), slicing software (Cura). • Reverse engineering: 3D scanning, point cloud to CAD model.		
III	**Computer-Aided Manufacturing (CAM)** • Introduction to CAM: CNC machining processes (milling, turning). • CNC programming: G & M codes, manual part programming basics. • Toolpath generation: contour, pocket, drilling, surface machining. • Cutting parameters: speed, feed, depth of cut, tool selection. • Post-processing: converting toolpaths to machine-specific G-code. • Simulation and verification: detecting collisions, material removal simulation. • Integration of CAD/CAM/CAE: digital thread, smart manufacturing. • Introduction to additive manufacturing (advanced 3D printing).	1	35%

Textbooks:

- Zeid, I., & Sivasubramanian, R., *CAD/CAM: Theory and Practice*, 3rd Ed., McGraw-Hill.
- Groover, M. P., & Zimmers, E. W., *CAD/CAM: Computer-Aided Design and Manufacturing*, Pearson.

Reference books:

- Rao, P. N., *CAD/CAM: Principles and Applications*, 4th Ed., McGraw-Hill.
- Chang, T. C., Wysk, R. A., & Wang, H. P., *Computer-Aided Manufacturing*, 4th Ed., Prentice Hall.
- McMahon, C., & Browne, J., *CAD/CAM: Principles, Practice and Manufacturing Management*, 2nd Ed., Addison-Wesley.
- Kruth, J. P., et al., *Advances in Integrated Design and Manufacturing in Mechanical Engineering*, Springer.

Online Platforms:

- NPTEL – CAD/CAM – Prof. A. K. Jha (IIT Roorkee) / Prof. K. S. Reddy (IIT Kharagpur)

List of Experiments:

Part A: CAD Modelling

- Introduction to CAD Interface – Sketching, constraints, basic extrude/revolve.
- Part Modelling – Creating a mechanical component (e.g., flange, bracket) with features.

- Advanced Modelling – Loft, sweep, patterns, and shell features.
- Assembly Modelling – Creating an assembly (e.g., piston-cylinder, gearbox) with mates.
- Drawing Generation – Generating 2D engineering drawings with dimensions, tolerances, GD&T.
- Surface Modelling – Basic surface creation and editing.
- **Part B: CAE and Analysis**
  7. Static Structural Analysis – Stress analysis of a bracket under load.
  8. Thermal Analysis – Heat distribution in a simple component.
  9. Modal Analysis – Natural frequency and mode shapes of a cantilever beam.
  10. Topology Optimization – Weight reduction of a component while maintaining strength.
  Part C: CAM and Manufacturing (4 Sessions)
  11. Introduction to CAM Workspace – Setting up stock, tools, and machining coordinates.
  12. 2.5 Axis Milling – Generating toolpaths for pocketing and contouring.
  13. CNC Simulation – Verifying toolpaths and generating G-code.
  14. Integration Project – Design a part, simulate analysis, generate toolpaths, and prepare for 3D printing/CNC machining.
- **Part D: Additive Manufacturing**
  15. 3D Printing – Slicing a CAD model, setting print parameters, and printing a sample part.
  16. Reverse Engineering – Using a 3D scanner (or photogrammetry software) to capture and remodel an object.

SUBJECT CODE: BTME505

SUBJECT NAME: OPERATIONS RESEARCH
Course Objectives:

- To introduce mathematical modelling and optimization techniques for decision-making in engineering and management.
- To formulate and solve linear programming, transportation, assignment, and network problems.
- To apply probabilistic models and simulation for analysing queuing, inventory, and replacement systems.
- To prepare students for solving real-world industrial optimization problems in manufacturing, logistics, and supply chain.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate and solve LP, transportation, and assignment problems using appropriate algorithms.
CO2	Apply network models (CPM, PERT, shortest path) for project and logistics planning.
C03	Analyze queuing systems and inventory models for service and manufacturing systems.
C04	Use software tools (Excel Solver, Python) to model and solve OR problems.

Unit	Content	Credit	Weightage
I	**Deterministic Optimization Models** • Introduction: OR methodology, model formulation, applications in engineering.	1	30%

	• Linear Programming (LP): graphical method, simplex method, Big-M method, two-phase method. • Duality theory: primal-dual relationships, economic interpretation, dual simplex method. • Sensitivity analysis: objective function coefficients, resource constraints (RHS changes). • Transportation problem: North-West Corner, Least Cost, Vogel's Approximation, MODI method. • Assignment problem: Hungarian method, unbalanced problems. • Integer Programming: branch and bound, cutting-plane methods (introductory).		
II	**Network Models and Decision Analysis** • Project scheduling: CPM (Critical Path Method), PERT (Project Evaluation and Review Technique). • Network flows: shortest path (Dijkstra's), maximum flow (Ford-Fulkerson), minimum spanning tree. • Dynamic programming: principle of optimality, applications (knapsack, equipment replacement). • Decision analysis: decision-making under uncertainty, risk, decision trees, expected monetary value. • Game theory: two-person zero-sum games, pure and mixed strategies, graphical method. • Sequencing: n-jobs on 1/2/m machines, Johnson's algorithm.	1	35%
III	**Probabilistic Models and Advanced Topics** • Queuing theory: characteristics (M/M/1, M/M/c), performance measures (L, W, Lq, Wq). • Inventory models: EOQ, EOQ with shortages, quantity discounts, probabilistic inventory models. • Replacement models: individual and group replacement. • Simulation: Monte Carlo simulation, discrete-event simulation (concepts only). • Markov chains: states, transition probability, steady-state analysis. • Introduction to non-linear programming and metaheuristics (genetic algorithms, simulated annealing).	1	35%

Textbooks:

- Taha, H. A., *Operations Research: An Introduction*, 10th Ed., Pearson.
- Hillier, F. S., & Lieberman, G. J., *Introduction to Operations Research*, 11th Ed., McGraw-Hill.

Reference books:

- Winston, W. L., *Operations Research: Applications and Algorithms*, 4th Ed., Cengage.
- Gupta, P. K., & Hira, D. S., *Operations Research*, S. Chand Publications.
- Ravindran, A., Phillips, D. T., & Solberg, J. J., *Operations Research: Principles and Practice*, 2nd Ed., Wiley.

- Kanti Swarup, Gupta, P. K., & Man Mohan, *Operations Research*, 18th Ed., Sultan Chand & Sons.

Online Platforms:

- NPTEL – Operations Research – Prof. G. Srinivasan (IIT Madras)

SEMESTER-VI

SUBJECT CODE: BTME601

SUBJECT NAME: AUTOMOBILE ENGINEERING

Course Objectives:

- To understand the layout, construction, and working principles of major automobile systems.
- To analyse the design and functioning of engine systems, transmission, steering, suspension, and brakes.
- To study vehicle dynamics, safety systems, and emerging automotive technologies.
- To prepare students for careers in automotive design, testing, manufacturing, and maintenance.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the construction and working of major automobile systems.
CO2	Analyze transmission systems and select appropriate components for given applications.
C03	Evaluate steering, suspension, and braking systems for safety and performance.
C04	Understand vehicle dynamics principles and electronic control systems.

Unit	Content	Credit	Weightage
I	**Vehicle Structure and Engine Systems** • Introduction: vehicle classification, layout (front/rear wheel drive, 4WD), chassis, frame, body types. • Engine: construction details, valve mechanisms, cooling, lubrication, fuel injection systems. • Supercharging and turbocharging, engine performance curves. • Engine emission control: catalytic converters, EGR, SCR, particulate filters. • Alternative power plants: electric vehicles (BEV), hybrid systems (HEV, PHEV), fuel cells.	1	25%
II	**Transmission and Drivetrain Systems** • Clutches: single/multi-plate, centrifugal, electromagnetic. • Manual transmission: gearboxes (sliding mesh, constant mesh, synchromesh), gear ratios. • Automatic transmission: torque converters, planetary gear sets, hydraulic controls. • CVT (Continuously Variable Transmission), DCT (Dual Clutch Transmission). • Driveline: propeller shaft, universal joints, differential, final drive, axle types. • 4WD and AWD systems.	1	25%
III	**Chassis Systems – Steering, Suspension, and Brakes** • Steering systems: Ackermann principle, steering	1	25%

	geometry, power steering (hydraulic, electric). • Suspension systems: types (leaf spring, coil spring, air suspension), independent suspension. • Shock absorbers, anti-roll bars, vehicle ride and handling. • Braking systems: drum brakes, disc brakes, hydraulic, pneumatic, vacuum assisted brakes. • ABS (Anti-lock Braking System), ESC (Electronic Stability Control), traction control. • Wheels and tires: types, specifications, tire dynamics.		
IV	**Vehicle Dynamics, Safety, and Emerging Technologies** • Vehicle dynamics: stability, cornering, rollover, weight distribution. • Safety systems: seat belts, airbags, crumple zones, crash testing. • Automotive electronics: sensors, actuators, ECUs, CAN bus, infotainment systems. • Autonomous vehicles: sensors (LiDAR, radar, cameras), ADAS (Advanced Driver Assistance Systems). • Electric and hybrid vehicle technology: battery systems (Li-ion), BMS, motor controllers, regenerative braking. • Automotive materials: composites, aluminum, high-strength steels.	1	25%

Textbooks:

- Giri, N. K., *Automotive Mechanics*, 12th Ed., Khanna Publishers.
- Srinivasan, S., *Automotive Mechanics*, 3rd Ed., McGraw-Hill.

Reference books:

- Heitner, J., *Automotive Mechanics*, 2nd Ed., Cengage.
- Newton, K., Steeds, W., & Garrett, T. K., *The Motor Vehicle*, 13th Ed., Butterworth-Heinemann.
- Gillespie, T. D., *Fundamentals of Vehicle Dynamics*, SAE International.
- Bosch Automotive Handbook, 10th Ed., Wiley.

Online Platforms:

- NPTEL – Automobile Engineering – Prof. C. S. Shankar Ram (IIT Madras) / Prof. B. K. Roy (IIT Kharagpur)

SUBJECT CODE: BTME602

SUBJECT NAME: FINITE ELEMENT ANALYSIS

Course Objectives:

- To introduce the fundamental concepts and mathematical formulation of the Finite Element Method (FEM).
- To develop skills in discretization, element formulation, and assembly for 1D, 2D, and 3D problems.
- To apply FEA software for solving structural, thermal, and dynamic problems in mechanical engineering.
- To interpret and validate FEA results through analytical and experimental methods.

Course Outcomes: At the end of the course students shall be able to

CO1	Derive stiffness matrices for basic 1D and 2D finite elements.
CO2	Assemble global stiffness matrices and solve for displacements, stresses, and temperatures.
C03	Perform static structural, thermal, and modal analyses using commercial FEA software.
C04	Interpret FEA results, check convergence, and validate with analytical solutions.

Unit	Content	Credit	Weightage
I	**Fundamentals and 1D Finite Element Analysis** • Introduction: historical background, applications, and advantages of FEM. • Basic steps: discretization, element formulation, assembly, solution, post-processing. • Weighted residual methods, variational formulation. • 1D elements: bar element, truss element, shape functions, stiffness matrix formulation. • Direct stiffness method for spring and bar systems. • Assembly of global stiffness matrix, application of boundary conditions. • Solution techniques: Gaussian elimination, matrix inversion. • Thermal analysis: 1D heat conduction element.	1	30%
II	**2D Finite Element Analysis** • Review of plane stress, plane strain, and axisymmetric problems. • 2D element types: CST (Constant Strain Triangle), LST (Linear Strain Triangle), quadrilateral elements. • Shape functions for triangular and quadrilateral elements, natural coordinates. • Isoperimetric formulation: Jacobian transformation, numerical integration (Gauss quadrature). • Assembly and solution for 2D structural problems. • 2D heat transfer elements: conduction, convection. • Introduction to plate and shell elements.	1	35%
III	**Advanced Topics and Dynamic Analysis** • 3D solid elements: tetrahedral and hexahedral elements. • Finite element modelling: meshing techniques, mesh convergence, quality metrics. • Dynamic analysis: natural frequency and mode shapes (modal analysis), eigenvalue problems. • Transient dynamic analysis: time integration methods (explicit/implicit). • Introduction to nonlinear FEA: material nonlinearity (plasticity), geometric nonlinearity (large deformation), contact analysis. • Verification and validation: error estimation, comparison with analytical solutions.	1	35%

	• Practical considerations: pre-processing, solution, post-processing in commercial software.		

Textbooks:

- Logan, D. L., *A First Course in the Finite Element Method*, 7th Ed., Cengage Learning.
- Rao, S. S., *The Finite Element Method in Engineering*, 6th Ed., Butterworth-Heinemann.

Reference books:

- Cook, R. D., Malkus, D. S., Plesha, M. E., & Witt, R. J., *Concepts and Applications of Finite Element Analysis*, 4th Ed., Wiley.
- Zienkiewicz, O. C., Taylor, R. L., & Zhu, J. Z., *The Finite Element Method: Its Basis and Fundamentals*, 7th Ed., Elsevier.
- Bhatti, M. A., *Fundamental Finite Element Analysis and Applications*, Wiley.
- Chandrupatla, T. R., & Belegundu, A. D., *Introduction to Finite Elements in Engineering*, 4th Ed., Pearson.

Online Platforms:

- NPTEL – Finite Element Method – Prof. C. S. Upadhyay (IIT Madras) / Prof. R. Krishnakumar (IIT Madras)

List of Experiments:

Part A: Fundamentals & 1D Problems (4 Sessions)

- Introduction to FEA Software – GUI, workflow, units, material assignment.
- 1D Truss Analysis – Analyse a plane truss, compare with analytical results.
- 1D Heat Transfer – Conduction in a composite wall, temperature distribution.
- Beam Bending – Cantilever beam under point load, deflection and stress analysis.
- **Part B: 2D Problems (4 Sessions)**
  5. 2D Plane Stress – Bracket Analysis – Stress concentration at a hole, mesh refinement study.
  6. 2D Axisymmetric Analysis – Pressure vessel under internal pressure.
  7. 2D Heat Transfer with Convection – Heat sink analysis, temperature contours.
- Plate with a Crack – Linear elastic fracture mechanics (LEFM) introduction (optional).
- **Part C: Advanced & Dynamic Problems (4 Sessions)**
  9. 3D Solid Analysis – Stress analysis of a connecting rod or gear tooth.
  10. Modal Analysis – Natural frequencies and mode shapes of a cantilever plate.
  11. Transient Thermal Analysis – Cooling of a heated block over time.
  12. Nonlinear Analysis – Large deflection of a slender beam (geometric nonlinearity).

SUBJECT CODE: BTME603

SUBJECT NAME: MECHATRONICS

Course Objectives:

- To introduce the interdisciplinary nature of mechatronics, integrating mechanics, electronics, and computing.
- To understand sensors, actuators, microcontrollers, and their interfacing for system control.
- To design and model basic mechatronic systems using simulation tools and hardware.
- To apply mechatronic principles to real-world applications like robotics, automation, and smart systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Select appropriate sensors and actuators for a given mechatronic application.

CO2	Interface sensors and actuators with microcontrollers (Arduino/Raspberry Pi).
C03	Program and implement basic control algorithms (e.g., PID) for system regulation.
C04	Design and integrate subsystems to build a functional mechatronic system.

Unit	Content	Credit	Weightage
I	**Foundations of Mechatronics and Sensing** • Introduction: definition, key elements, mechatronic design process. • Sensors and transducers: classification, characteristics (range, accuracy, sensitivity). • Types: displacement (LVDT, potentiometer), velocity (tachogenerator), force (strain gauge), temperature (thermistor, RTD, thermocouple), proximity (optical, inductive, capacitive). • Signal conditioning: amplification, filtering, ADC/DAC. • Introduction to microcontrollers: architecture of Arduino/PIC, GPIO, PWM. • Interfacing sensors with microcontrollers.	1	30%
II	**Actuation and Control Systems** • Actuators: classification (electrical, pneumatic, hydraulic). • Electrical actuators: DC motors, stepper motors, servo motors, BLDC motors. • Drive circuits: H-bridge, motor drivers (L298N, L293D). • Pneumatic and hydraulic actuators: cylinders, valves, circuits. • Control systems: open-loop vs closed-loop, PID control (theory and implementation). • PLC basics: ladder logic, timers, counters, simple automation. • Introduction to programmable automation controllers (PACs).	1	35%
III	**System Integration and Applications** • System modelling: block diagrams, transfer functions, state-space representation. • Data communication: serial (UART), I²C, SPI, CAN bus, Ethernet. • Introduction to robotics: robotic arm kinematics, mobile robots. • Industrial automation: CNC machines, automated assembly lines, Industry 4.0 concepts. • Design case studies: pick-and-place robot, temperature control system, elevator control. • Introduction to IoT in mechatronics: cloud monitoring, smart systems.	1	35%

Textbooks:

- Bolton, W., *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, 7th Ed., Pearson.
- Alciatore, D. G., & Histand, M. B., *Introduction to Mechatronics and Measurement Systems*, 5th Ed., McGraw-Hill.

Reference books:

- Shetty, D., & Kolk, R. A., *Mechatronics System Design*, 2nd Ed., Cengage.
- Bishop, R. H. (Ed.), *The Mechatronics Handbook*, 2nd Ed., CRC Press.
- Gadre, D. V., *Programming and Customizing the Arduino*, McGraw-Hill.
- Rizal, M., & Iqbal, M., *Mechatronics: Principles and Applications*, Elsevier.

Online Platforms:

- NPTEL – Introduction to Mechatronics – Prof. S. K. Saha (IIT Delhi) / Prof. B. K. Roy (IIT Kharagpur)

List of Experiments:

Part A: Sensors and Interfacing

- Digital and Analog I/O – LED blinking, reading a potentiometer, PWM control.
- Temperature Monitoring System – LM35 sensor interfacing, display on serial monitor/LCD.
- Distance Measurement – Ultrasonic sensor (HC-SR04) with Arduino, object detection.
- Speed and Position Sensing – IR sensor with encoder disk for RPM measurement.
- **Part B: Actuation and Motor Control**
  5. DC Motor Control – Direction and speed control using H-bridge (L298N).
  6. Stepper Motor Control – Unipolar/Bipolar stepper motor with driver, position control.
  7. Servo Motor Control – Angular positioning using PWM.
  8. PID Temperature Control – Using a heating element and temperature sensor (simulated or real).
- **Part C: Integrated Systems and Automation**
  9. Obstacle-Avoiding Robot – Using ultrasonic sensor and DC motors.
  10. PLC-Based Traffic Light Control – Using ladder logic (software simulation or hardware).
  11. Automated Conveyor System – Using IR sensors and motors for object sorting.
  12. Final Project – Design a mechatronic system (e.g., automated plant watering system, CNC plotter, robotic arm with joystick control).

SUBJECT CODE: BTME604

SUBJECT NAME: ROBOTICS AND AUTOMATION

Course Objectives:

- To introduce fundamental concepts of robotics, including kinematics, dynamics, and control.
- To understand robotic sensors, actuators, and end-effectors for automation applications.
- To study robotic programming, path planning, and integration into automated systems.
- To explore advanced topics in industrial automation, collaborative robots, and emerging trends.

Course Outcomes: At the end of the course students shall be able to

CO1	Model robotic manipulators using D-H parameters and solve forward/inverse kinematics.
CO2	Plan trajectories and implement basic control strategies for robotic systems.

C03	Integrate sensors and actuators into automated robotic work cells.
C04	Simulate and program robots using ROS and other industry tools.

Unit	Content	Credit	Weightage
I	**Robotics Fundamentals and Kinematics** • Introduction: history, classifications (serial, parallel, mobile), applications in manufacturing, healthcare, etc. • Robot anatomy: links, joints, actuators, end-effectors (grippers, tools). • Spatial descriptions: coordinate frames, rotation matrices, homogeneous transformations. • Forward kinematics: Denavit-Hartenberg (D-H) parameters, kinematic modelling of manipulators. • Inverse kinematics: analytical and numerical methods, workspace analysis. • Velocity kinematics: Jacobian matrix, singularities, statics.	1	30%
II	**Dynamics, Trajectory Planning, and Control** • Dynamics: Euler-Lagrange formulation, Newton-Euler equations, dynamic modeling. • Trajectory planning: joint-space vs. Cartesian-space planning, polynomial trajectories, via points. • Robot control: PID control, computed-torque control, force control. • Sensors in robotics: position, velocity, force/torque, vision systems (intro). • Actuators: electric (DC, stepper, servo), hydraulic, pneumatic. • End-effector design: grippers, tool changers, compliance devices.	1	35%
III	**Automation and Advanced Robotics** • Industrial automation: robotic work cells, programmable logic controllers (PLCs), human-machine interfaces (HMIs). • Mobile robotics: locomotion, sensors (LiDAR, IMU), SLAM (Simultaneous Localization and Mapping). • Robot programming: lead-through, offline programming (OLP), ROS basics. • Collaborative robots (cobots): safety standards, applications. • AI in robotics: machine learning for perception and control, neural networks. • Emerging trends: soft robotics, swarm robotics, exoskeletons, ethical considerations.	1	35%

Textbooks:

- Craig, J. J., *Introduction to Robotics: Mechanics and Control*, 4th Ed., Pearson.
- Sciavicco, L., & Siliciano, B., *Modeling and Control of Robot Manipulators*, 2nd Ed.,

Springer.

Reference books:

- Niku, S. B., *Introduction to Robotics: Analysis, Control, Applications*, 3rd Ed., Wiley.
- Spong, M. W., Hutchinson, S., & Vidyasagar, M., *Robot Modeling and Control*, 2nd Ed., Wiley.
- Groover, M. P., *Industrial Robotics: Technology, Programming, and Applications*, 2nd Ed., McGraw-Hill.
- Asada, H., & Slotine, J. J., *Robot Analysis and Control*, Wiley.

Online Platforms:

- NPTEL – Robotics – Prof. C. Amarnath (IIT Bombay) / Prof. S. K. Saha (IIT Delhi)

SUBJECT CODE: BTME605

SUBJECT NAME: ADDITIVE MANUFACTURING LAB

Course Objectives:

- To introduce the principles, processes, and applications of additive manufacturing (3D printing).
- To develop hands-on skills in operating different AM technologies (FDM, SLA, SLS, etc.).
- To design and optimize parts for AM using CAD and slicing software.
- To evaluate the mechanical properties, accuracy, and surface finish of printed components.
- To apply AM for rapid prototyping, tooling, and functional part production.

Course Outcomes: At the end of the course students shall be able to

CO1	Operate FDM and SLA printers safely and independently.
CO2	Design parts optimized for additive manufacturing (DFAM).
C03	Select appropriate AM processes and materials for given applications.
C04	Post-process and evaluate the quality of printed parts.

Practical List

Part A: Fundamentals and FDM Processes

Experiment 1: Introduction to AM Technologies

- Overview of AM processes: ASTM categories (FDM, SLA, SLS, SLM, BJT, etc.).
- Demonstration of FDM and SLA printer components and working principles.
- Safety protocols and material handling (filaments, resins, powders).

Experiment 2: CAD Modeling for AM

- Design a simple part (e.g., gear, bracket) using CAD software.
- Apply design for additive manufacturing (DFAM) principles: overhangs, support structures, orientation.
- Export file in STL/3MF format and check for errors (manifold, watertight mesh).

Experiment 3: Slicing and G-Code Generation

- Use slicing software (Cura/PrusaSlicer) to import an STL file.
- Set printing parameters: layer height, infill density, print speed, support settings.
- Generate and analyze G-code, simulate print.

Experiment 4: FDM Printing and Post-Processing

- Operate an FDM printer: bed leveling, filament loading, print initiation.
- Print a test part (e.g., calibration cube, Benchy).
- Post-processing: support removal, sanding, acetone vapor smoothing (for ABS).

Part B: Advanced AM Processes and Materials (Weeks 5–8)

Experiment 5: Stereolithography (SLA) Printing

- Introduction to vat polymerization: SLA vs. DLP.
- Prepare a CAD model in PreForm (or similar) with supports and orientation.
- Print a high-resolution part (e.g., microfluidic device, jewelry).
- Post-processing: IPA washing, UV curing.

Experiment 6: Multi-Material and Composite Printing

- Print a part using dual-extrusion FDM (e.g., dissolvable supports, two colors).
- Introduction to composite filaments (carbon fiber, wood-filled).
- Evaluate mechanical properties (tensile test comparison).

Experiment 7: Design Optimization for AM

- Use topology optimization software (Fusion 360, ANSYS) to redesign a bracket for weight reduction.
- Compare traditional vs. optimized design: mass, stiffness, print time.
- Print and test both designs (destructive/non-destructive).

Experiment 8: Metal AM Simulation (Software-Based)

- Introduction to metal AM (SLM, DED) using simulation software (Netfabb, ANSYS).
- Simulate thermal stresses and distortion in a metal part.
- Analyze support structure design for metal printing.

Part C: Applications and Quality Control

Experiment 9: Functional Part Production

- Design and print a functional assembly (e.g., piston-cylinder, gear train) with moving parts.
- Clearance and tolerance testing for snap-fits, hinges.
- Assembly and functional testing.

Experiment 10: Reverse Engineering and AM

- 3D scan an object using a structured light scanner or photogrammetry.
- Edit the mesh (MeshMixer, Blender) and prepare for printing.
- Print and compare with original part (dimensional accuracy).

Experiment 11: Mechanical Testing of AM Parts

- Print tensile, flexural, or impact test specimens (ASTM/ISO standards).
- Conduct mechanical testing (UTM) and compare with injection-molded/cast parts.
- Analyze failure modes and anisotropy.

Experiment 12: Final Project – AM Product Development

- Identify a real-world problem (e.g., custom prosthesis, drone component, tooling jig).
- Complete the AM workflow: design → simulation → slicing → printing → post-processing → testing.
- Documentation: design files, process parameters, cost analysis, validation report.

MK UNIVERSITY

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SEMESTER-VII

SUBJECT CODE: BTME701

SUBJECT NAME: POWER PLANT ENGINEERING

Course Objectives:

- To study the working principles, design, and operation of various power plants (thermal, nuclear, hydro, renewable).
- To analyse thermodynamic cycles, performance parameters, and efficiency improvements in power generation.
- To understand fuel handling, combustion, emission control, and environmental regulations.
- To explore emerging trends in sustainable power generation and smart grid integration.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze thermodynamic cycles and evaluate performance of steam, gas, and combined cycle plants.
CO2	Compare different power generation technologies based on efficiency, economics, and environmental impact.
C03	Design basic layouts of hydro, wind, and solar power systems.
C04	Understand emission control technologies and regulatory frameworks.

Unit	Content	Credit	Weightage
I	**Introduction and Steam Power Plants** • Energy sources: conventional vs. non-conventional, global energy scenario. • Thermodynamic cycles: Rankine cycle (simple, reheat, regenerative), efficiency improvements. • Coal-based steam power plants: layout, boiler types (water-tube, fire-tube), superheaters, economizers, air preheaters. • Steam turbines: impulse, reaction, compounding, governing. • Condensers: types, cooling towers (natural draft, mechanical draft). • Feedwater system: pumps, heaters, deaerators. • Performance parameters: heat rate, specific fuel consumption, plant load factor.	1	25%
II	**Gas Turbine, Combined Cycle, and Nuclear Plants** • Gas turbine power plants: Brayton cycle, components (compressor, combustion chamber, turbine). • Performance: effect of regeneration, intercooling, reheating. • Combined cycle power plants (CCPP): integration of gas and steam cycles, cogeneration. • Nuclear power plants: fission, reactor types (PWR, BWR, PHWR), components, safety systems. • Fuel handling: uranium enrichment, waste disposal.	1	25%

	• Comparative analysis: economics, environmental impact.		
III	**Hydroelectric and Renewable Energy Plants** • Hydroelectric plants: classification (impoundment, run-of-river, pumped storage), components (dam, penstock, turbine, generator). • Turbine types: Pelton, Francis, Kaplan, selection criteria. • Wind power: wind turbine types, power curve, site selection, grid integration. • Solar power: photovoltaic (PV) systems, solar thermal power (parabolic trough, tower). • Biomass, geothermal, and ocean energy systems. • Energy storage: batteries, flywheels, compressed air energy storage (CAES).	1	25%
IV	**Plant Economics, Environment, and Emerging Trends** • Power plant economics: capital cost, levelized cost of electricity (LCOE), tariff structure. • Environmental aspects: air pollutants (SOx, NOx, PM), control technologies (FGD, SCR, ESP). • Carbon capture and storage (CCS). • Smart grids: demand-side management, microgrids, distributed generation. • Hybrid power plants: solar-wind, wind-diesel. • Future trends: ultra-supercritical plants, IGCC, hydrogen economy, small modular reactors (SMRs).	1	25%

Textbooks:

- Nag, P. K., *Power Plant Engineering*, 4th Ed., McGraw-Hill.
- El-Wakil, M. M., *Power Plant Technology*, McGraw-Hill.

Reference books:

- Raja, A. K., Srivastava, A. P., & Dwivedi, M., *Power Plant Engineering*, 2nd Ed., New Age International.
- Black & Veatch, *Power Plant Engineering*, Springer.
- Haywood, R. W., *Analysis of Engineering Cycles*, 4th Ed., Pergamon Press.
- Sarkar, D. K., *Thermal Power Plant: Design and Operation*, Elsevier.

Online Platforms:

- NPTEL – Power Plant Engineering – Prof. P. K. Das (IIT Kharagpur) / Prof. R. K. Singh (IIT Roorkee)

SUBJECT CODE: BTME702

SUBJECT NAME: VIBRATIOND AND NOISE CONTROL

Course Objectives:

- To analyse free and forced vibrations in single and multi-degree-of-freedom systems.
- To study vibration isolation, damping, and balancing techniques.
- To introduce fundamentals of acoustics, noise measurement, and control strategies.
- To apply analytical, computational, and experimental methods to solve vibration and noise problems in mechanical systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate and solve equations of motion for SDOF and MDOF vibration systems.
CO2	Design vibration isolators and absorbers for mechanical systems.
C03	Measure and analyze noise levels using sound level meters and frequency analyzers.
C04	Recommend noise control strategies for industrial/machinery applications.

Unit	Content	Credit	Weightage
I	**Fundamentals of Vibrations** • Introduction: importance, classification (free/forced, damped/undamped), applications. • Single degree-of-freedom (SDOF) systems: free vibration (undamped, damped), natural frequency, damping ratio. • Logarithmic decrement, Coulomb damping. • Forced vibration: harmonic excitation, magnification factor, phase angle, rotating unbalance. • Vibration isolation and transmissibility. • Vibration measuring instruments: vibrometers, accelerometers.	1	30%
II	**Multi-Degree-of-Freedom and Continuous Systems** • Two degree-of-freedom (2-DOF) systems: equations of motion, natural frequencies, mode shapes. • Lagrange's equations for MDOF systems. • Matrix methods: eigenvalue problems, orthogonality of modes. • Vibration absorbers: tuned mass dampers (TMD). • Continuous systems: longitudinal, transverse, and torsional vibrations of bars/beams. • Introduction to finite element method (FEM) for vibration analysis.	1	35%
III	**Noise Control and Acoustics** • Fundamentals of acoustics: sound pressure level (SPL), decibel scale, frequency analysis. • Human hearing, weighting networks (A-weighting), noise criteria. • Noise measurement: sound level meters, octave band analysis. • Noise sources in machinery: gear noise, bearing noise, aerodynamic noise. • Noise control strategies: absorption, damping, isolation, barriers, enclosures. • Vibrations and noise in structures: structure-borne vs. air-borne noise. • Case studies: automotive NVH, machinery noise control.	1	35%

Textbooks:

- Rao, S. S., *Mechanical Vibrations*, 6th Ed., Pearson.
- Singiresu S. Rao, *The Finite Element Method in Engineering*, 6th Ed. (for advanced topics).

Reference books:

- Thomson, W. T., & Dahleh, M. D., *Theory of Vibration with Applications*, 5th Ed., Pearson.
- Inman, D. J., *Engineering Vibration*, 5th Ed., Pearson.
- Beranek, L. L., & Vér, I. L., *Noise and Vibration Control Engineering*, 2nd Ed., Wiley.
- Norton, M. P., & Karczub, D. G., *Fundamentals of Noise and Vibration Analysis for Engineers*, 2nd Ed., Cambridge University Press.

Online Platforms:

- NPTEL – Mechanical Vibrations – Prof. S. K. Dwivedy (IIT Guwahati) / Prof. Anil Kumar (IIT Roorkee)

List of Experiments:

Part A: Vibrations

- **Free Vibration of SDOF System** – Determine natural frequency and damping ratio of a spring-mass system.
- **Forced Vibration of SDOF System** – Study response under harmonic excitation, resonance, and phase lag.
- **Vibration Isolation** – Measure transmissibility ratio for different isolators.
- **Two-DOF System** – Experimental determination of natural frequencies and mode shapes.
- **Balancing of Rotating Masses** – Static and dynamic balancing on a balancing machine.
- **Modal Analysis of a Cantilever Beam** – Using FFT analyzer to extract natural frequencies and mode shapes.

- **Part B: Noise Control**

  7. **Sound Pressure Level Measurement** – Use of sound level meter, A-weighting, noise mapping.
  8. **Octave Band Analysis** – Frequency spectrum of noise from a fan or motor.
  9. **Noise Reduction Using Absorptive Materials** – Measure insertion loss of acoustic foam/barriers.
  10. **Vibration Damping** – Determine damping loss factor of a treated vs. untreated plate.

- **Part C: Simulation & Analysis**

  11. FEA Modal Analysis – Simulate natural frequencies of a bracket/plate using ANSYS.
  12. Integrated Project – Analyze NVH of a simple system (e.g., electric motor), propose control measures, and validate.

SUBJECT CODE: BTME703

SUBJECT NAME: RENEWABLE ENERGY SYSTEMS

Course Objectives:

- To introduce global energy scenarios, renewable energy potential, and sustainability frameworks.
- To analyse the working principles, design, and performance of major renewable energy systems (solar, wind, biomass, geothermal, etc.).
- To understand energy storage technologies, grid integration, and hybrid systems.
- To evaluate the economic, environmental, and social impacts of renewable energy projects.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze solar radiation data and design basic solar thermal and PV systems.
CO2	Evaluate wind resources and select appropriate wind turbine technology.
C03	Compare biomass conversion pathways and geothermal plant configurations.
C04	Model hybrid renewable energy systems with storage using simulation tools.

Unit	Content	Credit	Weightage
I	**Solar Energy Systems** • Solar radiation: measurement, extraterrestrial and terrestrial radiation, solar geometry, solar time. • Solar thermal systems: flat plate collectors, evacuated tube collectors, concentrating collectors (parabolic trough, dish, tower). • Thermal energy storage: sensible, latent, thermochemical storage. • Solar thermal applications: water heating, space heating, industrial process heat, solar cooling. • Photovoltaic (PV) systems: working principle, cell types (mono-Si, poly-Si, thin-film), PV module characteristics. • PV system design: stand-alone, grid-connected, hybrid systems, performance analysis.	1	30%
II	**Wind, Biomass, and Geothermal Energy** • Wind energy: wind resource assessment, Weibull distribution, Betz limit. • Wind turbine technology: HAWT vs. VAWT, components (blades, gearbox, generator, tower). • Wind farm layout, power curve, capacity factor. • Biomass energy: sources, conversion technologies (combustion, gasification, pyrolysis, anaerobic digestion). • Biofuels: biodiesel, bioethanol, biogas.	1	35%

	• Geothermal energy: resources, power plant types (dry steam, flash, binary cycle), direct use applications.		
III	**Emerging Systems, Storage, and Integration** • Ocean energy: tidal, wave, ocean thermal energy conversion (OTEC). • Small hydropower and pumped storage. • Energy storage: batteries (Li-ion, flow), hydrogen (production, storage, fuel cells), flywheels, compressed air energy storage (CAES). • Grid integration: smart grids, microgrids, virtual power plants, inverters and power electronics. • Hybrid renewable energy systems: design and optimization. • Economic analysis: LCOE (Levelized Cost of Energy), payback period, incentives. • Policy and sustainability: carbon credits, net-zero pathways, circular economy in renewables.	1	35%

Textbooks:

- Twidell, J., & Weir, T., *Renewable Energy Resources*, 4th Ed., Routledge.
- Sukhatme, S. P., & Nayak, J. K., *Solar Energy: Principles of Thermal Collection and Storage*, 4th Ed., McGraw-Hill.

Reference books:

- Kalogirou, S., *Solar Energy Engineering: Processes and Systems*, 3rd Ed., Academic Press.
- Manwell, J. F., McGowan, J. G., & Rogers, A. L., *Wind Energy Explained: Theory, Design and Application*, 3rd Ed., Wiley.
- Boyle, G. (Ed.), *Renewable Energy: Power for a Sustainable Future*, 4th Ed., Oxford University Press.
- IRENA Reports – Renewable Energy Technologies: Cost Analysis Series.

Online Platforms:

- NPTEL – Renewable Energy Engineering – Prof. V. V. N. Kishore (IIT Madras) / Prof. D. P. Kothari (IIT Delhi)

SEMESTER-VIII

SUBJECT CODE: BTME801

SUBJECT NAME: COMPOSITE MATERIALS

Course Objectives:

- To introduce the fundamentals of composite materials, including classification, constituents, and manufacturing processes.
- To analyse micromechanics and macro mechanics of composite materials, including stress-strain relationships and failure theories.
- To design and analyse composite laminates using classical lamination theory.
- To evaluate mechanical behaviour, failure modes, and applications of composites in aerospace, automotive, and structural engineering.

Course Outcomes: At the end of the course students shall be able to

CO1	Classify composite materials and select appropriate constituents for specific applications.
CO2	Predict elastic properties using micromechanics models.
C03	Apply classical lamination theory to analyze stress and strain in composite laminates.
C04	Evaluate failure of composites using appropriate failure criteria.

Unit	Content	Credit	Weightage
I	**Introduction and Micromechanics** • Introduction: definition, historical development, advantages and limitations of composites. • Classification: particle-reinforced, fibre-reinforced (continuous/discontinuous), laminated composites. • Constituent materials: fibres (glass, carbon, aramid), matrices (polymeric, metallic, ceramic). • Micromechanics: rule of mixtures, Halpin-Tsai equations, prediction of elastic constants (E_1, E_2, ν_{12}, G_{12}). • Thermal and hygral properties of composites. • Manufacturing processes: hand lay-up, filament winding, pultrusion, autoclave curing, RTM.	1	30%
II	**Macro mechanics and Failure Theories** • Stress-strain relations for anisotropic, orthotropic, and transversely isotropic materials. • Transformation of stresses and strains, off-axis loading. • Classical lamination theory (CLT): assumptions, ABD matrix, laminate stacking sequence. • Failure criteria: maximum stress, maximum strain, Tsai-Hill, Tsai-Wu. • Interlaminar stresses and edge effects. • Environmental effects: moisture absorption, thermal cycling.	1	35%
III	**Design, Analysis, and Applications** • Laminate design: symmetric, balanced, quasi-isotropic	1	35%

	laminates. • Stiffness and strength optimization. • Joining and repair of composites: adhesive bonding, mechanical fasteners. • Non-destructive evaluation (NDE) of composites: ultrasonic, X-ray, thermography. • Case studies: aerospace (wing structures, fuselage), automotive (body panels, drive shafts), sports equipment. • Introduction to nanocomposites and smart composites. • Sustainability and recycling of composite materials.		

Textbooks:

- Jones, R. M., *Mechanics of Composite Materials*, 2nd Ed., Taylor & Francis.
- Agarwal, B. D., Broutman, L. J., & Chandrashekhara, K., *Analysis and Performance of Fiber Composites*, 4th Ed., Wiley.

Reference books:

- Kaw, A. K., *Mechanics of Composite Materials*, 2nd Ed., CRC Press.
- Daniel, I. M., & Ishai, O., *Engineering Mechanics of Composite Materials*, 2nd Ed., Oxford University Press.
- Gibson, R. F., *Principles of Composite Material Mechanics*, 4th Ed., CRC Press.
- Mallick, P. K., *Fiber-Reinforced Composites: Materials, Manufacturing, and Design*, 3rd Ed., CRC Press.

Online Platforms:

- NPTEL – Composite Materials – Prof. Krishnan Kanny (IIT Madras) / Prof. N. S. Prasad (IIT Kharagpur)

SUBJECT CODE: BTME802

SUBJECT NAME: COMPUTATIONAL FLUID DYNAMICS

Course Objectives:

- To introduce the governing equations of fluid flow and heat transfer, and their numerical discretization.
- To understand finite difference, finite volume, and finite element methods for solving fluid dynamics problems.
- To apply CFD software for simulation, analysis, and validation of engineering flow problems.
- To develop skills in grid generation, turbulence modelling, and post-processing of CFD results.

Course Outcomes: At the end of the course students shall be able to

CO1	Derive and discretize governing equations of fluid flow and heat transfer.
CO2	Develop simple CFD codes (1D/2D) using finite difference/volume methods in Python.
C03	Perform CFD simulations of laminar/turbulent flows using ANSYS Fluent/Open FOAM.
C04	Generate appropriate grids and apply boundary conditions for engineering problems.

Unit	Content	Credit	Weightage
I	**Fundamentals and Governing Equations** • Introduction: history, applications, CFD workflow. • Governing equations: continuity, momentum (Navier-Stokes), energy, species transport. • Mathematical classification: elliptic, parabolic, hyperbolic PDEs. • Discretization methods: finite difference, finite volume, finite element overview. • Finite difference method (FDM): Taylor series, truncation error, consistency, stability. • Grid generation: structured vs. unstructured grids, mesh quality metrics.	1	30%
II	**Numerical Methods for Incompressible Flow** • Finite volume method (FVM): integral form, cell-centered vs. vertex-centered. • Discretization of convection-diffusion equations: upwind, central difference schemes. • Pressure-velocity coupling: SIMPLE, SIMPLEC, PISO algorithms. • Solution of algebraic equations: iterative methods (Gauss-Seidel, TDMA). • Boundary conditions: Dirichlet, Neumann, wall functions. • Steady and unsteady flows: explicit vs. implicit methods.	1	35%
III	**Turbulence Modelling and Advanced Topics** • Introduction to turbulence: scales, Reynolds averaging, RANS equations. • Turbulence models: $k-\epsilon$, $k-\omega$, SST, Spalart-Allmaras. • Introduction to LES and DNS. • Heat transfer modelling: forced/natural convection, radiation. • Multiphase flows: VOF, Eulerian-Eulerian models (introduction). • Post-processing: visualization, verification and validation (V&V), uncertainty quantification.	1	35%

Textbooks:

- Anderson, J. D., *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill.
- Versteeg, H. K., & Malalasekera, W., *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd Ed., Pearson.

Reference books:

- Ferziger, J. H., Peric, M., & Street, R. L., *Computational Methods for Fluid Dynamics*, 4th Ed., Springer.
- Patankar, S. V., *Numerical Heat Transfer and Fluid Flow*, CRC Press.
- Blazek, J., *Computational Fluid Dynamics: Principles and Applications*, 3rd Ed., Elsevier.
- Tannehill, J. C., Anderson, D. A., & Pletcher, R. H., *Computational Fluid Mechanics and*

Heat Transfer, 3rd Ed., CRC Press.

Online Platforms:

- NPTEL – Computational Fluid Dynamics – Prof. S. A. Vengadesan (IIT Madras) / Prof. K. M. Singh (IIT Bombay)

List of Experiments:

Part A: Fundamentals & Code Development

- 1D Heat Conduction – Finite difference solution using Python, compare with analytical solution.
- 1D Inviscid Burgers' Equation – Solve using FTCS and upwind schemes, study stability.
- 2D Laplace Equation (Potential Flow) – Solve over a rectangular domain with Python (Gauss-Seidel).
- Grid Generation – Create structured and unstructured meshes for a 2D airfoil using ANSYS Meshing/Pointwise.
- **Part B: Basic Flow Simulations**
  5. Laminar Pipe Flow – Simulate in ANSYS Fluent, validate with Hagen-Poiseuille solution.
  6. Flow over a Backward-Facing Step – Study separation and reattachment, compare with benchmark data.
  7. Natural Convection in a Square Cavity – Compare with benchmark (de Vahl Davis case).
  8. External Aerodynamics – Flow over a cylinder at Re=100, calculate drag coefficient and Strouhal number.
- **Part C: Advanced Applications**
  9. Turbulent Flow in a Pipe – Use $k - \epsilon$ model, compare velocity profile with log law.
  10. Heat Exchanger Simulation – Conjugate heat transfer in a double-pipe heat exchanger.
  11. Multiphase Flow – Water-air interface simulation using VOF method (dam break or sloshing).
  12. Final Project – Student-selected problem (e.g., automotive aerodynamics, HVAC duct flow, wind turbine wake analysis).